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A SERIES OF TEXTBOOKS PREPARED FOR THE STUDENTS OF THE INTERNATIONAL CORRESPONDENCE SCHOOLS AND CONTAINING IN PERMANENT FORM THE INSTRUCTION PAPERS, EXAMINATION QUESTIONS, AND KEYS USED IN THEIR VARIOUS COURSES

BUILDING STONE
LATHING, PLASTERING, AND TILING
COMMON BRICKWORK
ORNAMENTAL BRICKWORK AND TERRA COTTA
LIGHTING FIXTURES
USE AND DESIGN OF LIGHTING FIXTURES
ARCHITECTURAL DESIGN

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CONTENTS

BUILDING STONE

VARIETIES AND QUALITIES OF STONE

INTRODUCTION

1. In order to be able to decide which kind of stone is best to use under given conditions, a knowledge of the different kinds employed in building construction is very essential. It is not necessary for a builder to determine the exact composition of a stone, but his knowledge should be sufficient to aid him in selecting or specifying the kind of stone best adapted to the purposes for which it is intended. In this Section will be described some of the principal building stones of this country, classed according to composition and structure.

GRANITES

2. **Granites** are never found in layers, or strata; they consist of an aggregation of feldspar, quartz, and mica crystals, the principal impurities being hornblende and talc. The usual colors are white, gray, yellow, and shades of red, while the quality varies with the proportions of the component parts, the hardest stone containing more quartz and less feldspar and mica than the softer varieties. Hornblende renders the stone tough and heavy, feldspar makes it easier to cut and more susceptible to decomposition, while mica renders it friable.

3. Granite may be quarried easily, as it cleaves with regularity, and can usually be obtained in any size desired.

Owing to its hardness and toughness, however, great difficulty is experienced in working this stone, these qualities making it very expensive to cut and thus preventing its use in fine carving. Nevertheless, it is susceptible of a high polish, which makes a durable finish.

Granite is probably the best stone for foundations, and is extensively used in other positions requiring great strength; it is also put to such minor uses as flagging, thresholds, and water-tables. All kinds of granite are damaged considerably by the action of fire, which causes them to crack badly. They disintegrate at temperatures ranging from 900° to 1,000° F. The average weight of granite is about 166 pounds per cubic foot.

Granite is found in the eastern and western parts of the United States and in Canada, the gray variety occurring principally in the New England States and Virginia, while the red variety, which is usually harder, is found near the Bay of Fundy, on the islands of the St. Lawrence River, in Virginia, near Lake Superior, in Maine, and in many parts of the Rocky Mountains.

4. Gneiss.—**Gneiss**, which is also a crystallized rock, is constituted similarly to granite, but is distinguished from it by being arranged somewhat in parallel layers. Owing to this peculiarity, the rock splits into slabs having approximately parallel surfaces, thus making it valuable for walls, street paving, etc. Gneiss is called *stratified*, or *bastard, granite* by quarrymen.

5. Syenite.—The stone known as **syenite** consists of orthoclase and hornblende, which are frequently associated with mica and quartz. It has a granular texture resembling granite, is hard, tough, and somewhat coarse-grained, but will not take a polish.

6. Trap.—**Trap** is a rock consisting of hornblende and feldspar. It breaks into blocks with ease, but has no apparent granular structure. Owing to the difficulty of quarrying this rock in large pieces, it is seldom used as a building stone, although it makes an excellent aggregate for concrete.

LIMESTONES

7. The **limestones** used in building construction consist of lime in combination with one or more of the following constituents: silica, clay, talc, hornblende, mica, carbonate of magnesia, and iron. Fossil remains, such as shells, coral, etc., usually in a more or less pulverized condition, are frequently found in them. The term limestone is very general, and includes many varieties that differ entirely from one another in structure. Not all of these are suitable for building purposes, however, and care and experience are required to make the proper selection.

The principal limestones used for building purposes are the common, the fine-grained crystalline (usually called *marbles*), and the magnesian varieties. Limestones containing 10 per cent. or more of magnesia are called *magnesian*, and those having over 45 per cent. of that substance are termed *dolomites*. Dolomites are crystalline and granular in structure, and usually have a white or yellowish tinge.

In color, limestones are generally light gray, blue, or buff. Good examples are those obtained from Bedford, Indiana, and Bowling Green, Kentucky; both of these limestones are very durable, and may be classed among the best building stones. Limestones, although durable, are easily stained by the smoke in large cities. They are quite heavy, weighing about 150 pounds per cubic foot, and will take a high polish. They are also easy to work, but are easily destroyed by fire.

8. **Marble** is a crystallized limestone, and one of the most valuable building materials. It can be obtained in many colors—white, gray, red, blue, green, and black—and most of its varieties will take a high polish. One of the most important characteristics of marble is that it is easy to carve; the finer the grains of the stone, the more suitable it is for this purpose. The fine white-grained varieties that are especially prized for sculpture are called *saccharoid marble*.

Marble is a valuable material for exterior construction, as it resists frost and moisture well, but like all limestones it will not withstand fire.

Some of the finest varieties of white American marble are fcund at Lee, Massachusetts, and in the vicinity of Rutland, Vermont. The dark-blue marble from the Vermont quarries is very durable and has a very close grain. A fine black marble is quarried at Glens Falls, New York. Colored marbles, including gray, light and dark pink, buff, chocolate, etc., are found in Tennessee, Georgia, and many other places.

9. **Onyx Marble.**—The term **onyx** is applied to some kinds of marbles for the reason that their banded appearance somewhat resembles that of true onyx. These marbles have the same general composition as the common varieties of marble, but are formed in a purely chemical manner instead of in ordinary sedimentary beds. Their variegated colors are due to the presence of metallic oxides and other impurities.

Onyx can be worked and polished very readily, and is considered the handsomest of building stones, owing to its translucence and great variety of colors. It is used almost entirely for interior decoration, in wainscoting, mantels, etc. The stone presents the best appearance when cut across the grain, but this impairs the strength and necessitates a backing of stronger marble. Most of the onyx used in this country comes from Mexico and California.

SANDSTONES

10. **Sandstones** are so called because they are formed by the cementation of particles of sand—usually quartz grains—into rock. The character of the stone depends greatly on the nature of the cementing material. If the grains have been cemented by fusion, or under great pressure, the stone is nearly as hard as quartz; this variety is known as *quartzite*, and is very strong and durable.

When the cementing material is silica, the stone usually has a light-gray color and is hard to cut; but if the grains are cemented by oxide of iron, the stone is either red or brown

and is much softer. With carbonate of lime as a cement, the result is a light-colored or gray stone, soft and easy to work, but does not, as a rule, weather well. Sandstone containing clay is the poorest, as it easily absorbs water, which, on freezing, rapidly disintegrates the stone.

Sandstones include some of the finest and most durable stones for outside construction. The ease of working them and their wide distribution cause them to be very extensively used. The stone is found in a great variety of colors—shades of gray, brown, buff, pink, red, drab, and blue being common—which depend largely on the quantity of iron oxides contained in the stone. The presence of these is not injurious, but no sandstone containing iron pyrites should be used for exterior work, as it is almost sure to become stained by rust.

Sandstones vary in texture from those in which the grains are almost imperceptible to those having grains like coarse sand; the finer the grain, the more easily can the stone be carved. Quarried sandstones usually hold considerable water, which renders them soft and easy to work; but nearly all become harder as the water evaporates, and the stone should not be subjected to heavy loads until the water is dried out.

11. **Blue shale, or bluestone,** is a variety of argillaceous, or clayey, sandstone having a bluish color. It is very hard and dense and makes an excellent material for foundations, flagging, etc. Bluestone is found in large quantities along the Hudson River, in the vicinity of Kingston, New York.

QUALITIES OF GOOD STONE

12. No branch of masonwork, from an architectural standpoint, is of greater importance than the selection of stone for structural purposes; and the qualities of stone, such as its strength and durability when exposed to variations of temperature and action of the weather, its permanence of color, etc., are points that should be studied with care.

13. Strength.—Whenever a stone is to be used for foundations, piers, lintels, bearing blocks, etc., its strength is a matter of importance. If the stone appears to be first class, its strength may be assumed as equal to the average strength of stones of that kind, as determined by experiment.

The cap and bond stones for piers carrying iron columns and the bearing blocks under the ends of the girders should be either granite, bluestone, or hard, blue, Vermont marble. For use in such situations, the safe bearing strength should not be assumed greater than one-tenth of the crushing strength. The stones in piers for warehouses and office buildings are often subjected to loads of from 60,000 to 70,000 pounds per square foot.

14. In Table I is given the load per square inch at which the different kinds of stone fail.

15. Weight of Stone.—The following are average weights per cubic foot of stone of the classes mentioned:

Marble, in blocks	170 pounds
Limestone, in blocks	150 pounds
Granite, in blocks	166 pounds
Sandstone, in blocks	139 pounds
Slate, in blocks	174 pounds

The New York, Boston, and Chicago building laws give the weight of building stones of all kinds, when laid in the wall, at 165 pounds per cubic foot, which is near enough for most computations.

16. Color.—In rural districts and places where little or no soft coal is consumed, light-colored stones may be used without any danger of becoming dirty or disfigured, while in very smoky cities they will get very dark in a few years. In such cases, the red or brown silicious, or flinty, sandstones are the most desirable; and next in value are the granites. The stone that retains its native color best is the most desirable to use; but, in localities where all classes of stone change, the one to be preferred is that in which the alteration is the least, and uniform throughout.

TABLE I

CRUSHING STRENGTH OF STONE

Kinds of Stone	Strength Pounds per Square Inch	Kinds of Stone	Strength Pounds per Square Inch
Granites—		*Marbles—*	
Staten Island, blue	22,250	Dorset, Vermont	7,610
Maine	15,000	Proctor, Vermont, blue	14,410
Quincy, Massachusetts	17,750	Lee, Massachusetts, white	13,440
Richmond, Virginia	21,250	Mill Creek, Illinois, drab	9,700
Cape Ann, Massachusetts	12,420	North Bay, Wisconsin, drab	20,000
	19,500	*Sandstones—*	
Westerly, Rhode Island	14,940		
Fall River, Massachusetts	15,940	Little Falls, New York, brown	9,850
Duluth, Minnesota	17,750	Belleville, New Jersey, gray and red	11,700
Maryland	19,430	[illegible]n	6,950
		[illegible]	4,350
Limestones—		[illegible]	17,700
Glens Falls, New York	11,475	Berea, Ohio, drab	7,250
Lake Champlain, New York	25,000		10,250
[illegible] York	20,700	[illegible]	8,850
Joliet, Illinois	16,900	[illegible]	7,450
Lime Island, Michigan	23,000	[illegible]	9,700
	18,000	[illegible]	6,800
Bardstown, Kentucky	16,250	[illegible]	13,500
Cooper County, Missouri	6,650	[illegible]	10,700
North River bluestone	19,820	[illegible] buff	6,250
		Dorchester, New Brunswick, freestone	9,150
Marbles—		Massillon, Ohio, yellowish drab	8,750
East Chester, New York	13,500	Warrensburg, Missouri, bluish drab	5,000
Italian, common	13,060		

17. Durability.—The durability of stonework is of prime importance, as on this property depends the life of a structure. It is evident, therefore, that buildings of importance should be constructed of the most durable stone that can be economically obtained in the locality in which the building is to be erected.

Table II, taken from a United States census, gives the length of time that the several varieties of stone named have lasted in New York City without material deterioration:

TABLE II

DURABILITY OF BUILDING STONE

Variety of Stone	Years
Brownstone, coarse	5 to 15
Brownstone, fine laminated	20 to 50
Brownstone, compact	100 to 200
Bluestone (blue shale)	100 to 200
Sandstone, Nova Scotia	50 to 100
Limestone, Ohio, best silicious	100 to 200
Limestone, coarse fossiliferous	20 to 40
Limestone, oolitic	30 to 40
Marble, coarse dolomite	40 to 50
Marble, fine dolomite	50 to 100
Granite	75 to 200
Gneiss	50 to 200

18. Probably ordinary variations of temperature test building stones most severely. Stones consist of particles cohering more or less closely, and an increase in temperature causes each particle to expand, tending to force apart those surrounding it, while with a lowering of temperature a corresponding contraction occurs. As the temperature is ever varying, there is a continual motion of the particles, which, although very small, will in course of time produce cracks and result in the slow and gradual destruction of the stone. Such changes are among the most potent causes of the disintegration of stone.

The effect of frost on stones saturated with moisture is always disastrous. The expansive force exerted by water in solidifying is nearly 140 tons per square foot; hence, a stone of open texture exposed to heavy rains and then to the action of frost must suffer deterioration in course of time. Sandstones are the most porous, and granites the least; for this reason, granite is best adapted for use in wet places, as in foundations.

19. When atmospheric gases are brought in contact with the exposed surfaces of some kinds of stone by rains, the durability of the stones is often affected. The changes are the results of oxidation and solution. When iron exists in stone in the form of pyrites, it becomes combined with the oxygen in the air and produces the discoloration known as *rust*. When very minute, these particles of iron pyrites are not injurious, and the only effect of the rust is to give the stone a yellowish tinge; but if the pieces are of considerable size, the oxidation will discolor the stone unevenly. Some authorities claim that the presence of pyrites in small quantities is beneficial to the stone, as it increases the tenacity by its cementing qualities.

20. Pure water has practically no effect on building stone. Rain, however, contains traces of nitric, sulphuric, and other acids, absorbed from the smoke and other impurities in the air, and when these are brought in contact with stones, they tend to dissolve all portions that are soluble. Lime and magnesia in the form of carbonates (as in all marbles and limestones) are, in particular, easily acted on; sandstones containing iron or lime suffer from the same causes, while granites are the least affected.

21. Heavy pounding or hammering has a tendency to destroy the cohesion of the grains and thus renders the stone more susceptible to climatic influences. Only granites and the hardest sandstones should be peen- or bush-hammered. The most durable surface for granite is *rock-faced*, as the crystalline facets, being but little disturbed in

the dressing, shed moisture readily. For other stones, however, a smooth surface is usually the best in a changeable climate. Quarrying by explosives often causes cracks in the stone that are so small as to be unseen until the application of the load increases them enough to make them visible. The fracture of stones in buildings is often due more to imperfect setting than to any lack of strength in the stone.

For some purposes, as for steps, door sills, paving, etc., the *hardness* of a stone is of importance, in which case granites and other hard stones are the most suitable.

22. Stone should always be laid on its natural bed wherever possible. If placed so that the layers, as found in the quarry, are vertical, water penetrates between them much more easily, and, in freezing, will very quickly split the stone. Stones, such as sill and belt courses, so placed that rain washes over them, will deteriorate much more rapidly than the rest of the masonry, and on this account should always be the most durable kinds.

In selecting building stone, it is often important to obtain a kind that possesses good fire-resisting properties. The fine-grained, compact sandstones endure fire the best; while the exposed surfaces of limestones and marbles become converted into lime by intense heat. Granites are more affected than sandstones, but less than limestones.

23. Seasoning Stone.—In order to evaporate the quarry water that most limestones and sandstones contain when freshly quarried, they should be exposed to the air for a considerable time before being used; this seasoning makes the stone harder and also more durable under the action of frost. It is supposed that the quarry water contains in solution considerable cementing material and that this is deposited when the water evaporates, firmly binding together the particles. It can readily be seen that all necessary cutting or carving on stone of this kind should be done as soon as possible after quarrying.

INSPECTION AND TESTS

24. A close inspection should be made of all stone before it is used, to see that the specified quality is being delivered. When large quantities of stone are to be used, it is even advisable to visit the quarry in order to make any necessary tests. The tests usually made to assist in determining the qualities of stone, as to durability, etc., are for *compactness* and *hardness*, *absorption* and *solubility*.

25. Compactness.—The densest and strongest stones are generally the most durable. An idea of the compactness may be obtained by examining, through a good magnifying glass, the surfaces of freshly fractured stone, which should be clear and bright, with the particles well cemented. A dull earthy-looking fracture indicates liability to quick deterioration, while if the stone gives forth a clear metallic sound when struck with a hammer, it is a good indication of its compactness.

26. Absorption.—The tendency of a stone to absorb water should be considered with regard to the effect on the appearance of the building. While a dense non-absorbent stone is restored to its original color by a heavy rain, one of open texture will quickly absorb the water, which carries dust and soot into the pores of the stone and thus makes it very dirty in a short time.

Generally, the most durable stones are those that absorb the least water. In order to test the absorptive qualities of a stone, a good average specimen should be thoroughly dried, carefully weighed, and immersed in water for 24 hours. When taken out, the surface moisture should be dried off and the piece weighed; from the gain in weight, a good idea of the value of the stone may be obtained. One that increases 10 per cent. in weight in 24 hours should be rejected, unless it can be proved that such stone has endured successfully the tests of time and weather. Even one absorbing 5 per cent. of water and containing a large proportion of clay is unsafe to use.

27. Solubility.—To determine whether a stone contains much easily soluble earthy or mineral matter, crush finely a sample of the stone and place it in a glass of water, letting the particles remain undisturbed for about ½ hour; then, give the contents of the glass a rotary motion by stirring. If the stonė contains much earthy matter, the water will assume a turbid appearance, while if it has only a small quantity, the water will remain clear.

As already stated, the air in manufacturing cities is very likely to contain traces of various acids that attack the stone when brought in contact with it by rain. To determine the probable effect of acids on stone, soak a piece in a dish of water containing a drop or two of muriatic or sulphuric acid. If there is a very noticeable action, it will be wise to further test the stone.

STONE CUTTING AND FINISHING

28. Before treating of stone masonry, the preliminary work of dressing the stones for the wall should first be considered. While it is not necessary for an architect to be an expert stone cutter, he should be thoroughly familiar with the general principles of the art in order to be able to specify the proper treatment for a certain class of work and to know when it is well done.

STONE-CUTTING TOOLS

29. In Fig. 1 are shown the various hammers used for cutting and dressing stone, which may be described as follows:

The **double-face hammer,** at (*a*), weighs from 20 to 30 pounds, and is used for breaking and roughly shaping the stones as they come from the quarry. The **face hammer,** at (*b*), is a lighter tool than the double-face hammer, but is used for the same purposes when less weight is required; it has one blunt and one cutting end, the latter being used for roughly dressing the stones preparatory to using the finer tools.

The **pick**, shown at (*c*), is used for coarsely dressing the softer stones; its length is from 15 to 24 inches, and the width at the eye is about 2 inches.

The **ax**, or **peen hammer**, shown at (*d*), is about 10 inches long, and has two cutting edges about 4 inches in

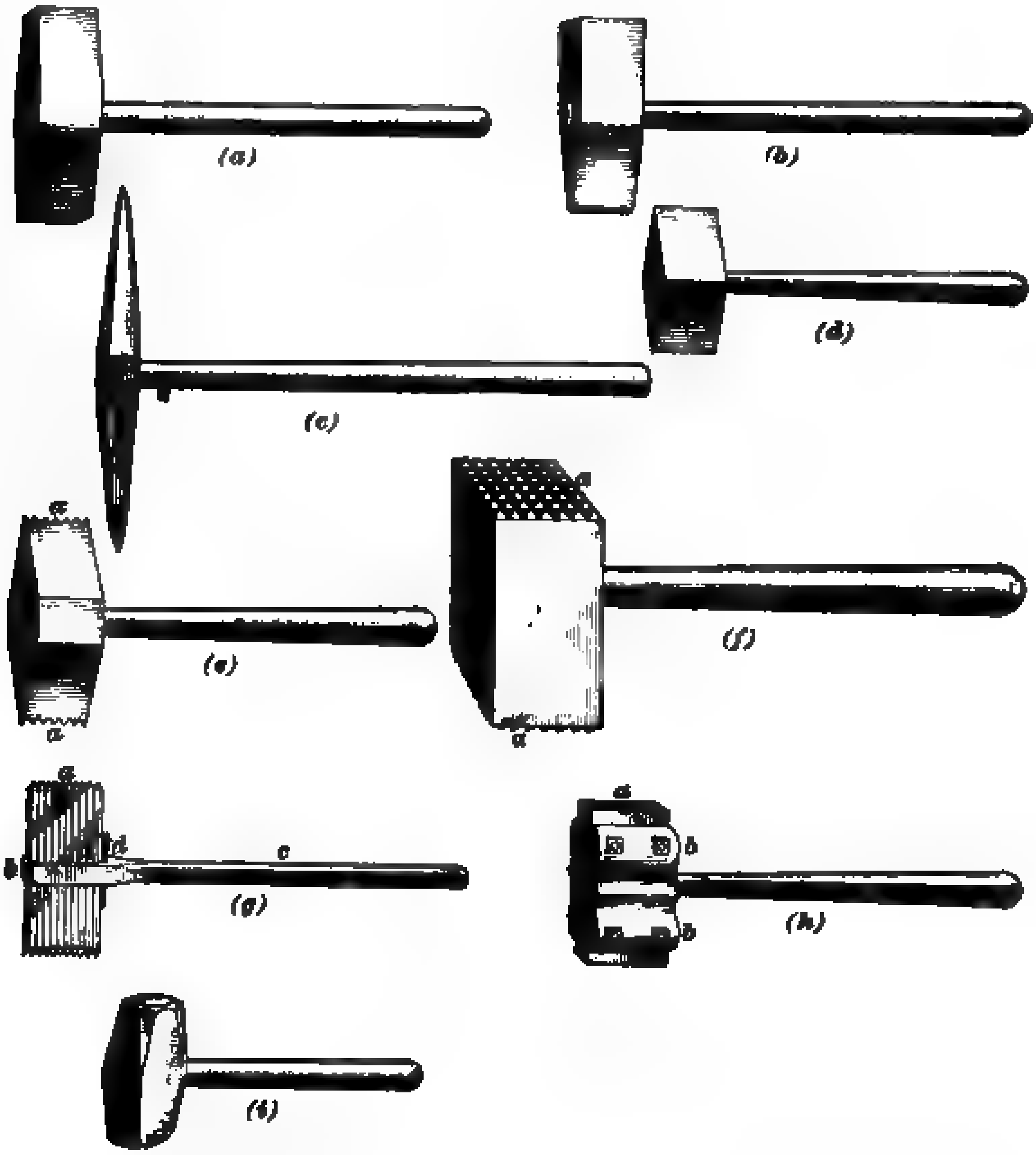


Fig. 1

length; it is used principally for making *drafts*, or margin lines, around the edges of stones, and also for dressing the faces, being used after the point, and before the patent hammer.

The **tooth ax**, shown at (*e*), has its cutting edges *a* notched to form teeth, the number of these teeth varying according

to the fineness of the work. It is used for roughing soft stones to an approximately flat surface before the finishing tool is used, but it is not used on hard stones, like granite and marble, as the points would become dull quickly and need constant sharpening.

The **bush hammer,** shown at (*f*), is from 4 to 8 inches long, with ends from 2 to 4 inches square and cut into a number of pyramidal points, as shown at *a*. This hammer is used for finishing limestones and sandstones after the surfaces have been made nearly even.

The **patent hammer,** shown at (*h*), is made of from four to ten thin blades of steel *a*, which are ground to an edge and held together by bolts, as shown at *b*, so as to form a single piece; it is used for finishing granite or hard limestone, and the number of blades required to give the proper fineness to the cutting is usually specified as four, six, eight, or ten cut.

The **crandall** is made as shown at (*g*), and consists of a malleable-iron handle *c* having a slot in the end *b*; in this slot are placed ten or twelve bars of $\frac{1}{4}$-inch square steel *a*, about 10 inches long and pointed at each end, which are held firmly in place by the key *d*. The crandall is used to complete the finish of sandstone after the surface has been partly worked by a tooth ax or a chisel.

The **hand hammer,** shown at (*i*), is used for drilling holes and in pointing and chiseling the harder rocks; it is about 5 inches in length, and weighs from 2 to 5 pounds.

The **mallet,** shown at (*j*), is used when the softer stones are to be cut; it is made of wood, the head being about 7 or 8 inches in diameter and 5 or 6 inches in height.

30. Chisels.—In Fig. 2 are shown the different chisels used for dressing stone. At (*a*) is shown the **point,** which is made of round or octagonal steel, 8 to 12 inches long, with one end pointed; it is used for chipping off the rough faces of the stone and reducing them to approximately plane surfaces, ready for the peen hammer, and also to give a rough finish to stone in *broach* and *picked work*.

At (*b*) is shown the **tooth chisel,** used only on soft stones, and serving much the same purpose as the tooth ax.

At (*c*) is shown a **drove chisel,** 2 or 3 inches wide at the

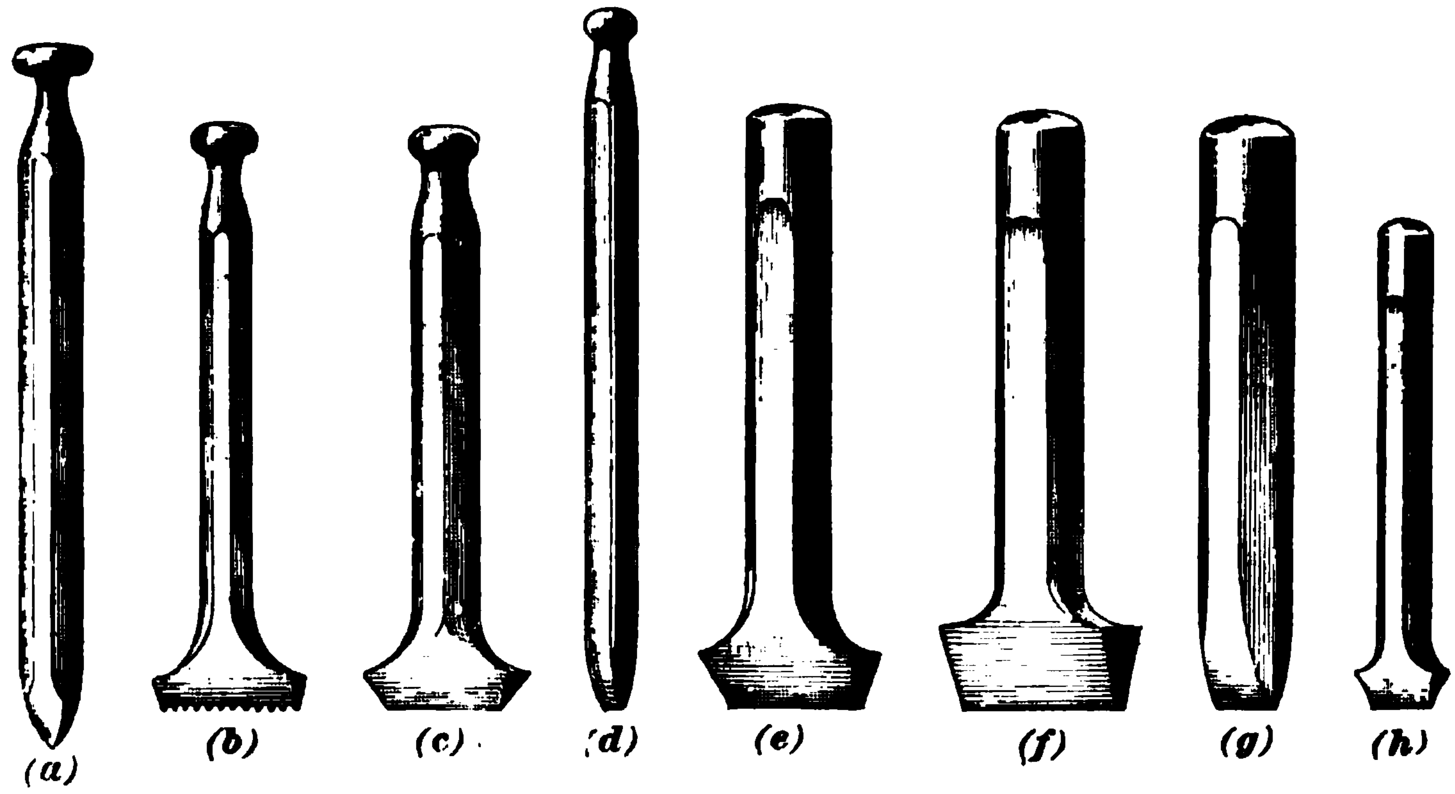


FIG. 2

end, which is used for cutting or driving the rough surfaces of the stone.

At (*d*), (*e*), (*g*), and (*h*) are shown other forms of chisels used for dressing soft stone.

At (*f*) is shown a **pitching chisel,** which is used for making pitched-face work.

31. Machine Tools.—Besides the hand tools just described, there are many machine tools employed to prepare the stone for the finer treatment to be given by hand work. These include *saws*, *cutters*, *planers*, *grinders*, and *polishers*.

The saws are either drag, circular, or band saws and each consists of a thin sheet of steel having blunt edges. The drag saw has a forward-and-backward movement, the cutting being done by the aid of sand and water fed into the cut. The operation of the others is similar, except as to the manner of driving.

The cutters are used on the rough stone to somewhat reduce the inequalities. Cutters and planers are made on two principles; one kind is used for homogeneous and tough stones, free from grit, etc., which are dressed by machines

resembling those used for iron and steel, and the other is for hard brittle stones whose structure necessitates a treatment resembling that employed in hand dressing. From the cutter and planer the stone goes to the grinder and polisher, which are practically alike, differing only in the fineness of the surface that they are capable of producing.

The polisher consists principally of a circular horizontal table on which the stone is fastened, the face to be polished being always turned upwards. This table with the stone revolves about a vertical axis through its center, and a metal plate that can be moved up and down, but will not revolve, is pressed on the stone. Sand and water are supplied between the plate and the stone, whose surface is thus abraded until the proper degree of smoothness is attained.

FINISH OF STONEWORK

32. Stereotomy.—The art of making patterns, or templets, to which a stone is to be cut to fill a certain place in an arch or other complicated piece of stonework, is called **stereotomy.** The architect makes a drawing of the intended stonework, showing where the joints in the face are to be located, and the stone cutter then details each block and cuts it to fit exactly with the others. It is therefore important for the architect to understand the different finishes to which stone is dressed, but it is not necessary for him to be able to make the templets for each stone.

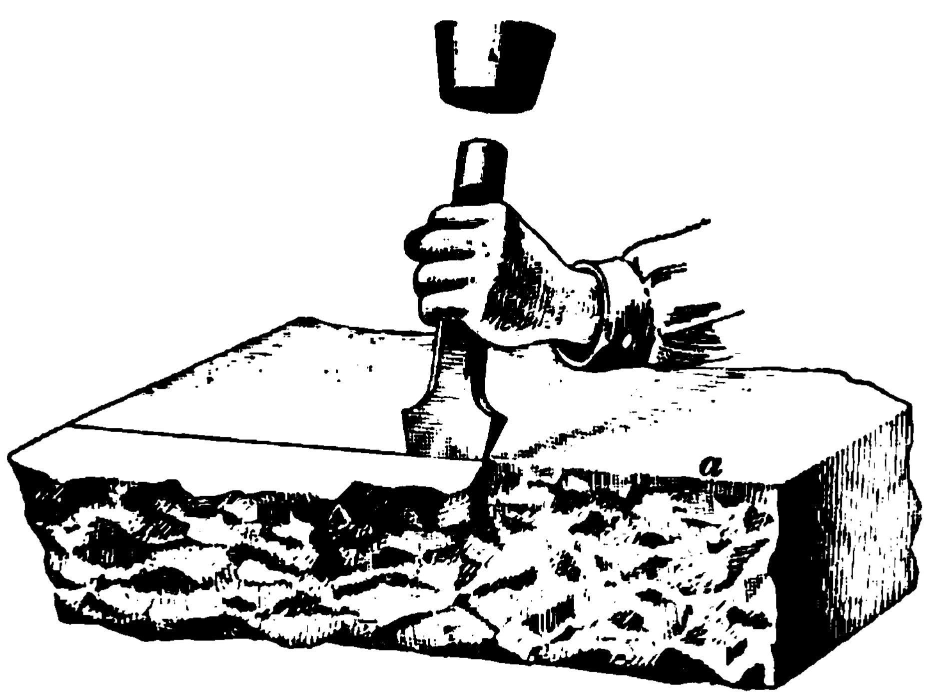


FIG. 3

33. Rock-Faced Work.—In Fig. 3 are shown **rock-faced,** or **pitch-faced, work** and the method of using the pitching chisel. The face of the stone is left rough, just as it comes from the

quarry, and the joints, or edges, are *pitched* off to a line, as shown at *a*. As very little work is required for this finish, rock-face dressing is cheaper than any other kind, especially when granite, bluestone, or hard limestone is used. Examples of rock-faced bluestone are shown in Figs. 4 and 5. Fig. 4 is a good specimen of *broken-range ashlar*, while Fig. 5 shows the general character of *coursed ashlar*. The different methods of laying up this work are treated in another Section.

34. Margins.—Building stones are often faced an inch or more from their edges. This dressed strip, which is shown in Figs. 7, 8, and 12, is known as the **margin,** or **draft line.** On soft stone, this margin is cut with a chisel, but on extra-hard stone, such as granite, it is usually cut with an ax, or peen hammer, in which case the surface would be plainer than the chiseled work and without the well-defined parallel channeling. The margin, or draft line, serves the purposes of emphasizing the joint, by contrasting the marginal plain surface with the rougher cut work in the center of the stone, and of giving a plain surface on which to work the angle of the joint, thus making a more true and accurate edge. Comparatively little margin work is now used for buildings. The feeling among architects is that the marginal tooling cuts up the texture of the stone and makes the work look too mechanical.

35. Pointed Work.—A pointed chisel is sometimes run over the face of a stone to knock off any large projections. This work is called **rough-** or **fine-pointed,** according to the number of times the work is gone over. In Fig. 6 is shown an example of rough-pointed work, while in Fig. 7 is shown an example of fine-pointed work.

36. Tooth-Chiseled Work.—One of the cheapest methods of working stone is known as **tooth-chiseled work,** which is done with the tooth chisel. A surface resembling pointed work, but not so regular, is thus obtained.

FIG. 4

18

Fig. 6

Fig. 6

Fig. 7

FIG. 8

FIG. 9

Fig. 10

Fig. 11

Fig. 12

Fig. 13

37. Broached Work.—Fig. 8 illustrates what is known as **broached work.** In this kind of work, the stone is dressed with a point, so as to leave continuous grooves over the surface. At *a* is shown the margin, or draft line, and at *b*, the broached center, which is cut in opposite directions in order to illustrate right- and left-hand broaching.

38. Tooled Work.—For **tooled finish,** a tooth chisel from 3 to 4½ inches wide is used, and the lines are continued across the width of the stone to the draft line (when one is used). When well done, this work makes a very good finish for soft stones.

39. Drove Work.—**Drove work** is somewhat similar to tooled work, but is generally executed on harder stone. There are two general classes of this work; namely, *hand drove* and *machine drove*, the former being shown in Fig. 9, and the latter in Fig. 10. Machine-drove work, it will be noticed, is more regular, and at the same time the cuts are a little deeper, although this is hardly apparent from the illustration. For a large quantity of cutting, machine work is cheaper than hand work, but is not so pleasing in appearance.

40. Crandalled Work.—In Fig. 11 is shown **crandalled work,** which, when well done, gives the stone a fine, pebbly appearance. This finish is especially effective for the red Potsdam and Longmeadow sandstones. In the Eastern States, it is used for sandstones probably more than any other finish.

41. Rubbed Work.—Sandstones and most of the limestones are often finished by *rubbing* their surfaces until they are perfectly smooth. By continuing the rubbing long enough, granite, limestone, and marble can be given a beautiful polish. Rubbed work is finished either by hand, using a piece of soft stone with water and sand, or by a machine, which performs the same operation. If the rubbing is done soon after the stones are sawed into slabs and are still soft, it is cheaply and easily performed, as the sawing makes the face of the stone comparatively smooth.

42. Bush-Hammered Work.—In Fig. 12 is shown the finish of a stone after having been **bush-hammered,** which leaves its surface full of points; this makes a very attractive finish for hard limestones and sandstones, but should not be used on the softer kinds.

43. Patent-Hammered Work.—A stone finished by a **patent hammer,** which is generally used on granite and hard limestone, is shown in Fig. 13. The stone is first dressed to a fairly smooth surface with the point and then finished with the patent hammer. The degree of fineness in the finish is determined by the number of blades in the hammer, the usual number being eight or ten. The ax may be used instead of the hammer, but much more time is required to obtain an equally good finish.

44. Vermiculated Work.—In Fig. 14 is shown a stone having a somewhat elaborate finish, which is known as **vermiculated** from its worm-eaten appearance. Stones so cut are used principally as quoins and in base courses. Owing to the cost, this dressing is not often used in the United States, except for very expensive work.

A simple method of obtaining the vermiculated effect is by the use of a patented sand-blast process. The sand employed for this work is the dust of carborundum, which is one of the hardest substances known. This dust is blown against the stone with high velocity by means of compressed air. While this dust, or sand, will rapidly cut and wear away hard surfaces, such as stone, it will not cut soft, yielding surfaces, because the latter do not suddenly stop its motion, but, by giving way slightly, permit the sand to sink in a short distance and then rebound. For this reason, the nozzle of the blowing machine is made of soft rubber. On those portions that it is desired to have raised, the stone to be cut is protected with beeswax, asphalt, or even heavy paper, and the remainder of the face of the stone is eaten away by the blast. When the proper depth has been reached, the sand blast is stopped, and the paper or asphalt cover is removed. It is then simply necessary to put on a few finishing touches

Fig. 14

with a pointed chisel, and the stone is ready to go in the structure.

The sand blast is also used to clean stonework that has become soiled and stained by smoke and dust.

45. Scale Work.—A pleasing and novel method of stone dressing, presenting a striking effect of light and shade, is illustrated in Fig. 15. The finish shown at (*a*) is obtained by cutting out rows of shallow flutes between the drafts of the stone with about a 1-inch tool. The flutes are about an inch wide, and are alternated so that each successive course "breaks into" the preceding one and forms with

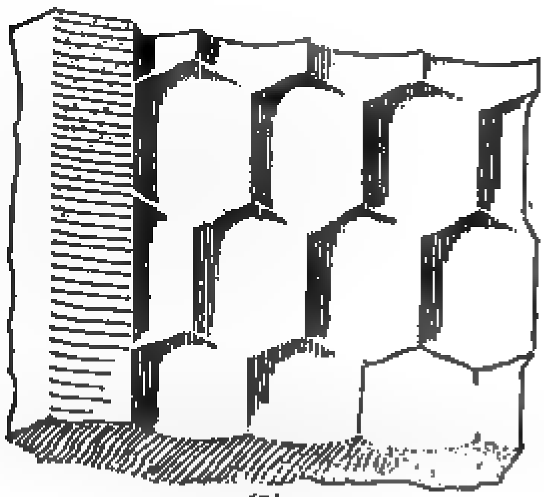


FIG. 15

it a series of hexagonal hollows, giving a honeycombed effect. The application of this finish to a window jamb is shown at (*b*).

This unique method is applicable, of course, only to soft stones, such as limestone; but to these it gives a beautifully crisp and varied surface. The cutting can be done either by hand or by machinery.

46. Rusticated Work.—Two examples of **rusticated work** are illustrated in Figs. 16 and 17, the former showing the stones with sharp edges and the latter the stones with rounded edges. The joint should always be at the upper edge of the rustication as shown at *a* in each illustration, as it is better protected from the weather when in this position. If the joint were placed at the lower edge of the rustication,

rainwater would lie on the lower horizontal surface and be liable to work its way back into the joint. The projection above the joint throws a heavy shadow at this point and strongly emphasizes the courses.

The height of the rustication should bear some simple proportion to the total height from joint to joint, and should not ordinarily be less than one-sixth of that height. The depth of the rustication should be about two-thirds of its height if the edges are square; if the edges are rounded, as in Fig. 17, the depth should be equal to the height. The

FIG. 16

FIG. 17

rustication is sometimes obtained by V joints, wherein the edges of the stone are chamfered or splayed. Rusticated masonry is sometimes laid with close, vertical joints, but is more frequently laid with the vertical, as well as the horizontal, joints rusticated. The latter method gives the better effect when the stones are of good length.

Rusticated work is used in massive buildings, usually for the first story, forming a heavy base treatment strong in shadowed joints, on which is placed the lighter and more ornate upper stories, where the joints are close or, if rusticated, very much smaller than those below. The surface of rusticated stonework is usually dressed in such a way as to give a rough appearance; this may be done either in rough-pointed, fine-pointed, or vermiculated work, as shown in

FIG. 18

Figs. 6, 7, and 14, respectively. These surfaces form a pleasing contrast with the plainer surfaces of the stones above. Good examples of rusticated masonry are to be seen in the Italian palaces of the Renaissance period.

CARVED WORK

47. In this Section, the preparation or cutting of stone surfaces has been taken up, and thus far has included rough rock faces and dressed faces, such as fine- and rough-pointed, patent-hammered, vermiculated, etc. The final step in the elaboration of stone is **carved work.** This requires more skill than common surface finishing, and in fact is an art requiring the skill of the sculptor. Carving is done both at the building, from scaffolds, and in the shop. Models in clay are frequently prepared, and plaster casts are made from these. The expert carver can reproduce the plaster model in stone with wonderful accuracy.

The scale and the minuteness with which carving should be executed depend on its height from the point or points at which it will be seen. Work that will be close to the eye of the observer should be carved out in great detail and fineness if the texture of the stone will permit, while work at some height from the eye should be bold and coarse in treatment to be effective. This latter point is often overlooked, and minute carving, beautiful in itself when viewed at close range, becomes a hazy maze when placed at such a height that its detail is practically lost.

The softer stones, being more easily worked, are more generally used for carving, as the expense is much less than when the granites and harder sandstones are employed. Great quantities of Indiana limestone are used for this purpose in the United States.

Besides figure work, carved ornament is utilized for the decoration of plain or molded band courses, capitals and bases of columns, pilasters, balustrades, friezes, panels, etc. Conventional or naturalistic plant growths usually form the base of the majority of ornamental motifs, but bands or

ribbons forming meanders and interlacings are much used in architectural work.

48. In Fig. 18 is shown an example of naturalistic carving in alto relief and in bas-relief. The forms used are plant and bird life. The two plants represented are the *Nuphar advena*, or water lily, and the *Typha latifolia*, or common cattail. Both of these motifs are copied closely from nature, and the detail is minutely carved, as the work is only a slight distance above the eye. The carving near the bottom of the panel is in alto relief and that in the upper portion is in bas-relief. The stone here used is marble, and the broad expanse of plain surfaces about the carving set off and frame it well. Owing to its rough texture and the size of its particles, coarser grained stone would not be suitable for such delicate carving.

49. In Fig. 19 is illustrated a similar panel in which the natural forms copied are the foliage and fruit of the oak and the mistletoe with squirrels perched on the limbs. This is a most beautiful piece of work and is very realistic. The distribution of the different treatments of relief is the same as in the previous example.

50. In Fig. 20 is shown a conventional scroll design that fills the entire panel in alto relief instead of a portion only, as in Figs. 18 and 19. In this respect, the carving is more in keeping with the panel moldings surrounding it, for these moldings are somewhat heavy for the bas-relief, as shown in Figs. 18 and 19. The design shown in Fig. 20 is a highly conventionalized acanthus, carved with great spirit. In respect to the harmony between the carving and the frame, this panel is the best of the three examples. The carving of the pilaster cap just above this panel is conventional, and repeats some of the leaf forms in the panel below.

51. A light type of rustication with panels of vermicular work is shown in Fig. 21. This example shows the effect of the vertical as well as the horizontal rustication. The cove carving of the cornice shows a treatment somewhat similar to

FIG. 19

Fig. 20

31

FIG. 21

Fig 22

Fig. 23

that of the pilaster in Fig. 20, although the carving is here done with much less snap and spirit. The scroll and the anthemion carved on the panel above the cove are conventional, as is in fact all the carving shown in this illustration. It would be difficult to say, except for the small leaf form in the scroll, which is based on the acanthus, from what the different forms here shown are derived. Figs. 14, 18, 19, 20, and 21 illustrate specimens of work executed on the City Hall of Philadelplia.

52. In Figs. 22 and 23 are illustrated two of the clustered columns in the Cincinnati Chamber of Commerce, designed by the late H. H. Richardson. The capitals of these columns are Romanesque, and are beautiful in design and execution. As will be observed, the carving is not very deep; this is due to the fact that the stone, which is granite, is exceedingly hard. These same capitals in a softer stone would be sharper and would have deeper cutting.

53. In Fig. 24 is shown the main entrance of the Temple Bethel in New York City, designed by Brunner and Tryon. This also is an example of Romanesque work, but is strongly Byzantine in feeling. All the carving here illustrated is quite close to the eye, and is most intricate and beautiful.

The adaptation of the Romanesque or Byzantine palmette, like the acanthus growth, to capitals, moldings, and plain surfaces is well illustrated here. Such work as that between the entrance tier of arches and the windows above, and that between the window arches and the large enclosing arch, would be lost if placed another story higher. In its present position, the work stands out clear and sharp. The rock face of the ashlar surrounding this elaborate doorway serves as a foil for the rich arabesque within the arch.

54. The entrance to the Cable Building, New York City, designed by McKim, Meade, & White, shown in Fig. 25, is an example of stonework where sculpture, the sister art to stone carving, is used in connection with the conventional plant growths, moldings, etc. already described and illustrated. The two draped figures in this example are quite

Fig 24

35

FIG. 25

close to the eye, and are therefore carved with considerable exactitude and detail. It is probable that these figures were carved from scaffolds at the building, after plaster models that had been previously approved by the architects. Note the beautiful, delicate carving of the Ionic capitals and cornice and the architrave above the door. This entrance is Greek in its inspiration, and the carving has been done with all the dainty grace and feeling of that style.

LATHING, PLASTERING, AND TILING

INTRODUCTION

1. Plastering may be described as a process by which the structural members composing the skeleton of the building fabric are clothed with plastic material that will render the structure more agreeable and habitable. This process is applicable to both the exterior and the interior of the structure. When used for exterior work, as in overlaying an inferior grade of stone or brick masonry, or in forming the covering material or wall sheathing to protect the framework, it is usually classified as **stucco work.**

2. Improved processes in the manufacture of brick and terra cotta, increased facilities for handling and cutting stone, and the desire for truthful construction, have all acted to drive stucco work out of the field. So strongly has this reaction influenced the public mind that the term stucco has become synonymous with everything that partakes of a spurious construction and fraudulent concealment. This change in public taste has practically limited the exercise of the plasterer's art to interior work. In this restricted sphere, however, there is ample opportunity for the exercise of good, honest, and skilful work, as no other substance has yet been produced that so well satisfies the requirements in the treatment of the large areas that occur in interiors.

3. The natural march of progress, and especially the introduction of modern fireproof construction, has led to the development of new methods and the improvement of old ones, so that at present the art of plastering has reached a high degree of perfection. To obtain such results, the prime requisites are good material and good workmanship. As these depend greatly on the specifications, the architect should be well acquainted with the nature and qualities of the materials and the proper methods of performing the work, in order to be able to make such specifications intelligently and to see that they are properly carried into execution.

4. Preparation of Walls for Plastering.—As plastering consists in coating the surfaces of walls and ceilings with thin layers of a plastic material, the surface to be covered should present every facility for the perfect adhesion and retention of the material that is to be applied. Generally speaking, there are only two kinds of bases that are coated with plaster and built up with subsequent layers to form a mass of sufficient thickness to withstand pressure and to retain a true and uniform surface. The first may be called a *lithic*, or *stone*, *base*, and the second, a *grille base*. In the former case, the plaster is laid directly on the face of the naked wall, which may be of either stone or brick; in the latter case, it is spread over a grille-like arrangement of wooden or metal strips, the edges of which are sufficiently separated to allow mortar to pass between them and fold over on the inner face, thus forming a *key*, or continuous clinch, that will effectually hold the mortar in position.

5. Lathing is the general term applied to the grille base just mentioned, and, as a rule, consists of wood in nonfireproof buildings, like ordinary frame dwellings, and of metal in fireproof structures. Although not absolutely necessary on brick and stone walls—as plaster adheres well to such surfaces—it is usually better to have some kind of lathing on exterior walls built of masonry. By this means, the plaster slabs are isolated from the wall, and a clear air space

intervenes. This arrangement insures a continually dry surface, which would otherwise be liable to dampness from the condensation of the heated air of the room on the cold surface of the walls, or from moisture penetrating the body of the wall during a period of wet weather.

The laths for exterior brick or stone walls are usually attached to vertical strips, 1 inch thick by 2 inches wide, called **furring**, which have been fixed to the walls by the carpenter; these strips are set at 12- or 16-inch centers, according to the grade of the work. For the interior walls in frame buildings, the laths are attached directly to the studs, or vertical posts, that form the framing of the walls. The laths for ceilings may be nailed directly to the under edges of the joists, or they may be attached to *cross-furring*—a series of strips, similar to those used on the walls—arranged at right angles to the joists and fixed at 12-inch centers; better results are obtained by the latter method, as the warping of the joists does not so much affect the lath.

LATHING

WOODEN LATHS

6. In old work, laths were generally made of oak, but in current practice, pine, spruce, and hemlock are used. The regular size of the lath strips is $\frac{1}{4}$ in. $\times$ $1\frac{1}{2}$ in., and 4 feet in length; this length regulates the spacing of the furring strips, studs, and joists in order to prevent waste of material.

Laths may be either split or sawed; split laths are better, as there are no cross-grained fibers to reduce their strength, while the presence of the cross-grained fibers in sawed laths makes them liable to curl and warp, due to the absorption of moisture from mortar. However, owing to their cheapness, sawed laths are generally used in the United States. To avoid the warping already mentioned, the laths should be straight-grained; to insure durability, they should be well seasoned

METAL LATHS

9. Steel in the form of wire netting and of expanded and perforated metal laths has come into very extensive use for the support of plastering, especially in fireproof structures. Plaster becomes more firmly attached to metal than to wood and will not become loosened by ordinary accidents, and as the steel is more or less completely embedded in the plaster, the plaster protects it effectively from fire, whereas wooden laths are only partially covered. Apart from the fireproof qualities, metal laths are valuable in wood construction from the fact that plaster laid on them will not crack nor fall off should shrinkage occur in the woodwork; and if the laths are set away from the joists and studs, these timbers will not show through the plaster, as is generally the case when plaster is laid on wooden laths.

Probably the best fireproof lathing consists of strong wire cloth stretched tightly over metal furrings. The difficulty of properly stretching wire cloth is one of the objections to its use, for unless the netting is quite rigid, it will yield considerably as the coats of plaster are applied; however, manufacturers now furnish stretchers, the use of which obviates this difficulty to a great extent. The objection has also been raised that both wire and expanded-metal lathing require much more plaster than wooden lathing. In this fact lies their great value, for, as the mortar is the fireproofing material, the lathing should be completely embedded in it; otherwise, the metal is perhaps of no greater value than wooden lathing. Numerous severe tests, both experimental and in actual fires, have demonstrated that plaster—especially the hard kinds—applied to wire cloth will successfully protect woodwork from fire if the wood is completely covered with it.

Wire laths may be had in numerous sizes; the size most extensively used has about $2\frac{1}{2} \times 2\frac{1}{2}$ meshes per square inch and is made of No. 20 gauge wire. It comes in rolls from 32 to 36 inches wide, but some manufacturers supply it in widths up to 8 feet. Metal laths may be had either plain.

painted, or galvanized. The latter form, while more expensive, is preferable, as it is much stiffer and less liable to rust than the plain kind. Painted laths are nearly as good as the galvanized, and cost considerably less.

10. Furring.—Wire lathing and plaster used to protect woodwork should not be in contact with the latter, but should be separated at least $\frac{1}{4}$ inch, while more space is advantageous. To secure this space, furring strips are necessary. These strips may either be woven into the wire cloth or be separate pieces fastened to the wood before the lathing is applied. In the latter case, the strips consist of corrugated or flat iron of proper width to give the required air space when set on edge—usually about $\frac{1}{2}$ or $\frac{3}{4}$ inch—and are fastened to the wood by small staples. The strips generally run lengthwise of the floorbeams and studding; if laid crosswise, they will not have such a firm bearing, and should either be placed closer together or heavier strips should be used.

A substitute for this kind of furring is made of $\frac{1}{8}$-inch rods spaced from 6 to 8 inches apart. These rods are kept away from the wood by separators made of small pieces of thin metal having the ends turned up from $\frac{1}{2}$ to 1 inch at right angles to the back, which is slotted to permit the insertion of staples. This furring should run across the joists, or studs, and the rods may be placed as close together as required.

11. Stiffened Wire Laths.—The use of separate furring strips forms an item of expense that may be avoided by substituting wire laths having ribs attached or woven into the cloth for plain wire laths. The first mentioned are called the *Clinton stiffened laths*, which consist of narrow strips of corrugated steel fastened to the netting at 8-inch intervals, crosswise to the length of the roll, by means of metal clips. The laths are nailed to the floor joists or studs with the strips next to the wood.

The second kind referred to are the *Roebling laths*. These laths are formed of ordinary wire cloth having **V**-shaped stiffeners woven into the cloth at distances of about 8 inches.

frame structures, the additional cost generally precludes their use; but even in such buildings, there are numerous places where metal laths may be of considerable advantage, while the increased expense is not very great. For example, cracks at corners of ceilings and partition walls can be largely prevented by bending a strip of wire cloth, or lath, to fit the angle, and nailing it to the joists or studs on either side. Another place where metal laths should be used is at the junction of a wooden partition and a brick wall, when there is no furring on the wall and especially when the partition is flush with it. If a strip of metal lath is lapped 12 inches on both wall and partition, cracks at the junction will be avoided. When plaster is applied to exterior brick walls having wooden lintels, difficulty is sometimes experienced from the plaster cracking at the joint or not sticking to the wood. To obviate this, the joint should be covered with a strip of metal lath fastened to both brickwork and lintel. The foregoing uses are only a few of the numerous valuable applications of metal lathing to wood construction; others will doubtless suggest themselves.

PLASTER BOARDS

15. Plaster boards are made of some fibrous material embedded in plaster of Paris, and are used chiefly as a substitute for lathing and the first coat of plastering, one face of the board being grooved, or rough, to make the plaster adhere well. The usual size of each piece is from $\frac{5}{8}$ to 1 inch thick, 16 inches wide, and 4 feet long. Plaster boards can be readily sawed and nailed, and may be put on very rapidly. They are fastened directly to the studs, furring, or joists. These boards are nearly as fireproof as terra-cotta tile, and on account of their lightness and the ease of setting them are sometimes used in place of tiling for suspended ceilings and elsewhere. As lathing and the first coat of plaster—and often the second coat—are not required when these boards are employed, the saving, taken in connection with their low cost, makes them a very cheap, yet effective, kind of fireproofing.

PLASTERING

PLAIN PLASTERING

MATERIALS

16. Up to quite a recent period, practically all the interior plastering in the United States was composed of lime, sand, and hair. When plaster is made of a good quality of lime that is well slaked and properly mixed with the other constituents, it is very durable; but much of the lime plaster now used is made of inferior materials, so that a great deal of it is practically valueless so far as durability is concerned.

The substances that enter into the composition of the mortar will depend on the nature of the surface to be coated, the order in which the layer is applied, and on the desired finish. For ordinary work, these are *lime*, *water*, *sand*, *hair*, and *plaster of Paris*.

17. Lime.—Many limes that make good mortar for other purposes, are unfit for use in plaster, as they contain more or less overburned hard lumps that resist the action of the water and fail to readily disintegrate. Eventually, these overburned particles will slake, or what plasterers call "pop," and cause small pieces of plaster to fly off. Walls and ceilings may sometimes be seen pitted all over from such checking.

In many places, a number of brands of lime may be had, and, unless the slaking qualities are known, care should be exercised in selecting one for plastering purposes. In any case, the best practice is not to use lime until it has been slaked at least a week, as even with the best limes considerable time is required for the slaking of all the particles.

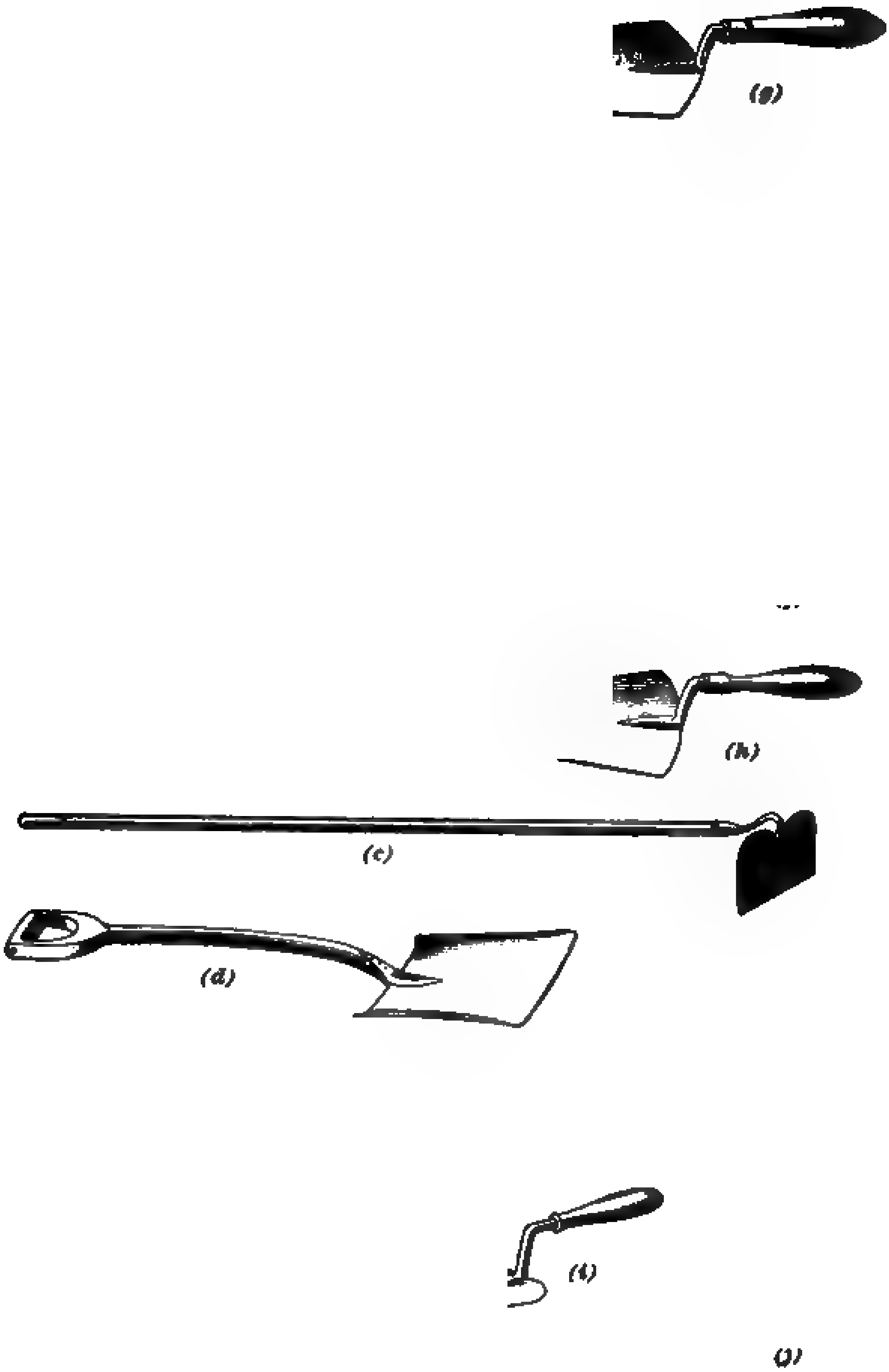


Fig 5

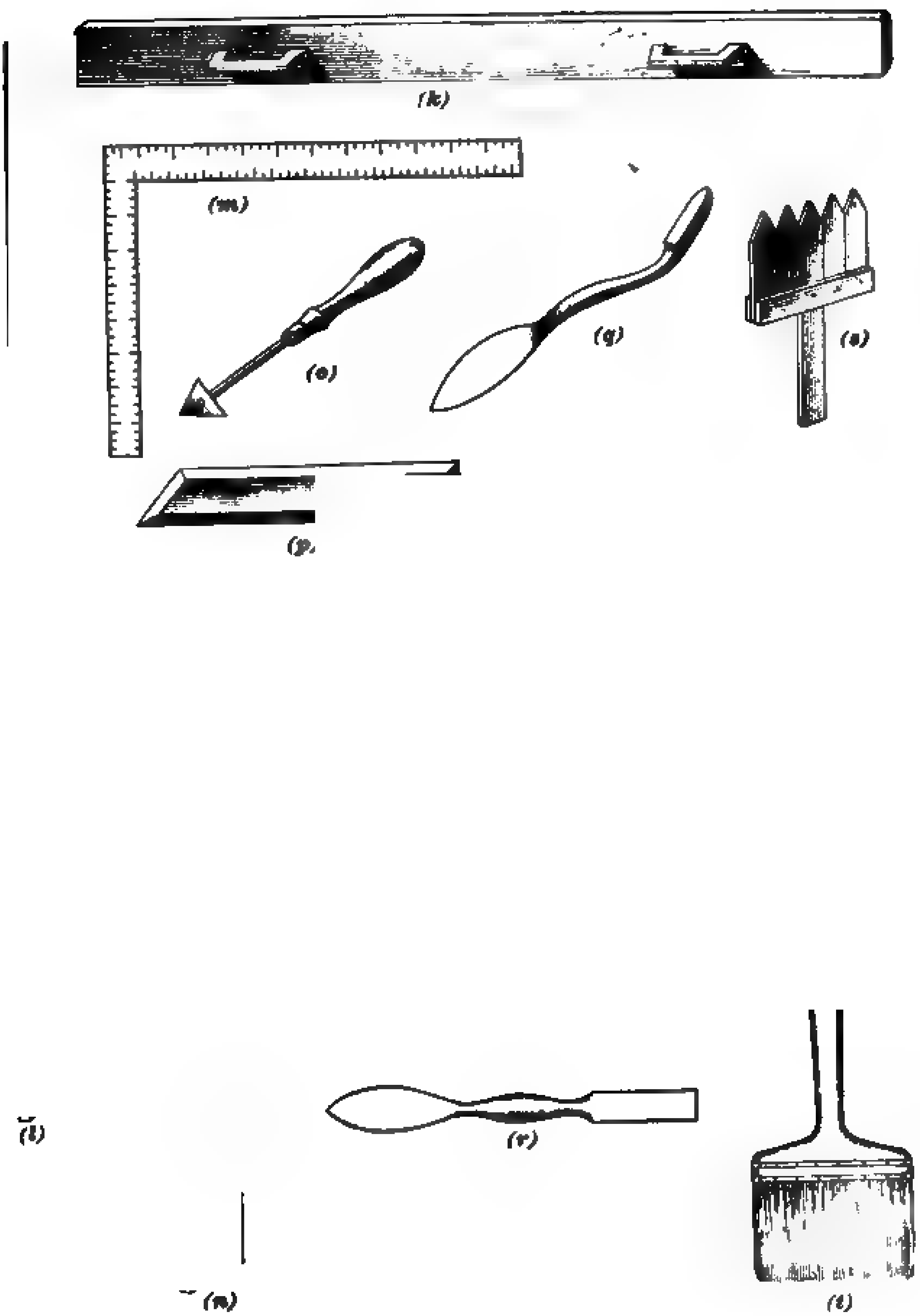


FIG. 5

Floats are used for smoothing, or floating, the surface of the second coat. At (*j*) is shown the **hand float**, which is merely a piece of board with a handle on the back. It is usually made of pine, but for producing the finished surface of very fine work, a cork face is sometimes used. For rough finish, the face of the float is often covered with carpet, etc. A two-handled float, called the **derby**, is shown at (*k*); this is a straightedged piece of wood, usually from 3 to 6 feet long, and is used for floating larger surfaces than can be readily worked with a one-handled float.

The **straightedge**, shown at (*l*), is a long piece of smooth board, having its under edge planed straight and true. It is used to test the walls and ceilings, in order to obtain plane surfaces.

The **square**, shown at (*m*), is used for testing the trueness of angles.

The **plumb**, shown at (*n*), is used to determine the perpendicularity of the surfaces by applying one of its straight sides to the surface. If the plumb-line, hanging freely, lies along a shallow groove cut into the face, parallel to the sides, the edges are true.

Jointing and **mitering tools**, shown at (*o*), (*p*), (*q*), and (*r*), are used for picking out and finishing angles and miters in moldings, etc.

The **comb**, shown at (*s*), is used for scratching the surfaces of the first and second coats of plaster, to form a good key for the ensuing coat. It consists merely of pieces of lath nailed together, and having one end sharpened, as shown.

Brushes of various kinds are used by the plasterer. That shown at (*t*) is used for dampening the surface of the plaster while it is being worked smooth.

Templets of various kinds are used for forming cornices and moldings. The templets are made of wood or sheet metal cut to the required outline, and are backed by wood. At (*u*) is shown one form of templet, which consists of a board *a*, to the beveled inner edge of which is attached a thin zinc or steel plate cut to the outline of the cornice, as at *b*. The strip *c* and handle *h* brace the board *a* firmly and keep

it square with the wall; *fg* represents a guide strip on which the strip *c* slides, and *de*, a line drawn on the ceiling flush with the outer edge of the board *a*, which is always kept along this line.

PROPORTIONS OF MATERIALS

22. The quantity of thoroughly slaked-lime paste that a barrel of ordinary lump lime will yield is about 2.75 barrels. The voids in sharp and clean sand are about one-third of its bulk. Probably the best plastering mortar is obtained by using sufficient lime paste to fill the voids in the sand $1\frac{1}{2}$ times; that is, the lime paste should be $\frac{1}{3}+\frac{1}{6}=\frac{1}{2}$ the volume of the sand, or one part of lime paste to two parts of sand. Measured in barrels, the lime (unslaked) and sand should be in the ratio of 1 to about $5\frac{1}{2}$. If lime is sold by weight, the same result will be had by using $2\frac{1}{2}$ barrels of sand to 100 pounds of dry lime. For 100 square yards of plastering laid $\frac{3}{8}$ inch thick, it will require, according to these proportions, about $2\frac{1}{2}$ barrels of lime and 14 barrels of sand. For the best class of work, the quantity of hair used should be $1\frac{1}{2}$ bushels to 1 barrel of lime for the first, or scratch, coat, and $\frac{1}{2}$ bushel to 1 barrel for the second, or brown, coat. Generally, however, plastering mortar contains less lime and hair than just stated, although these proportions are not too much for first-class work.

To regulate the proportion and uniform mixing of common plaster, unless the operations are constantly watched, is a difficult matter. The ordinary method of mixing is to add as much sand to the slaked lime as the mixer thinks it will stand, and it is hard for the architect to determine whether or not there is too much sand. Considerable experience, however, will enable one to judge the quality of the mortar by its appearance, or by trying it with a trowel when ready for use.

23. For a scratch and a brown coat on wooden laths with $\frac{3}{4}$-inch grounds, the following quantities are generally allowed for 100 square yards: 1,500 to 1,600 laths; 10 pounds

of three-penny lathing nails; 2½ barrels, or 500 pounds, of lime; 45 cubic feet, or 15 barrels, of sand; and 4 bushels of hair. For the best quality of white coat, the estimate is 90 pounds of lime to 50 pounds of plaster of Paris, and 50 pounds of marble dust. The same proportions can be used for large or small quantities.

MIXING PLASTERING MORTAR

24. Hand Mixing.—Outside of a few large cities, the great bulk of plastering mortar is mixed by hand, and for the best results requires very close regulation of materials and careful manipulation. The mixing should be performed as much as possible outside of the building to be plastered, so as not to make the interior damp from the vapor of slaking lime. When mortar is mixed in cold weather, it should be done under shelter, and in no case should frozen mortar be used.

A good quality of lime having been selected, it is slaked with clean water in a tight box, and allowed to stand for at least 24 hours—a week is better—to allow all the particles to be acted on. If there is any residue after slaking, the lime paste should be run through a fine-wire screen into another box. By using this paste as the base, the various coats may be made by adding other materials. The mixtures are generally classified as *coarse stuff*, *fine stuff*, *plasterer's putty*, *gauged stuff*, and *stucco*.

25. Coarse stuff is used for the first, or scratch, coat, and is made by mixing the proper quantities of sand and well beaten-up hair with slaked lime that has been reduced to a thin cream-like paste. (The sand is usually added last, but some authorities claim that better and tougher mortar is made by adding the sand soon after slaking.) On government work, the specifications require that the hair shall not be mixed with the lime paste until the plaster is to be applied. The materials are thoroughly incorporated by means of a hoe and then piled in a heap for a week; after which sufficient

water is mixed with the mortar to give it the proper consistency. Only a small batch should be wet at a time, and this should be laid on the lathing at once.

The common method is to mix the hair and sand with the lime as soon as it is slaked, and then throw the mortar into a pile, the entire operation not taking more than a few hours. This is a very poor way, as the lime will not slake thoroughly in such a short period, while the hot lime and steam will so char the hair as to affect materially the strength of the plaster.

26. Fine stuff is the pure lime that has been slaked to a paste in a trough by the addition of a small quantity of water, and afterwards further diluted by water until it is as thin as cream. The substance is then allowed to settle; when the excess of water appears clean, the lime held in suspension having subsided, it is drained off, and the moisture in the mass is allowed to evaporate until the stuff has become sufficiently stiff for use. If desired, a small quantity of white hair may be added to the fine stuff.

27. Plasterers' putty is practically fine stuff, but the creamy fluid having been strained through a fine sieve, the paste has been rendered much more velvety. It is always used without hair.

28. Gauged stuff consists of about three-fourths of the foregoing putty and about one-fourth of plaster of Paris. The plaster of Paris causes the mixture to set quickly, and the composition must be immediately used, no more being prepared than can be applied in 20 or 30 minutes. An excess of plaster in the mixture will cause the coat to crack. Gauged stuff is used as a finishing coat for walls and ceilings, and also for running cornices; for the latter work, equal portions of putty and plaster of Paris are used.

29. Stucco for interior work consists of two-thirds fine stuff and one-third sand. It is used as a finishing coat, the mixture being "whipped," and reduced to a thin paste by the addition of water.

30. Machine Mixing.—The advantages of machine-mixed mortar over mortar mixed by hand are that sufficient time is given for the lime to thoroughly slake, the hair and sand are added just before delivery, and the mixing is performed much more uniformly. Briefly, the process is as follows: Fresh lime is placed in revolving pans, enough water being added to slake the lime slowly. When this process is completed, the lime and water are run through screens and pumped into tanks, and allowed to remain there for about 3 weeks in order to finish slaking. When mortar is to be made, the paste is run into mixing pans, where hair and sand are added and the mass is thoroughly stirred until it is entirely homogeneous.

APPLYING THE PLASTER

31. Preliminary Examination.—Although the carpenter's specifications require that all surfaces be properly prepared for lath and plaster, and that suitable plaster grounds, such as shown at *e*, Fig. 6, be affixed to the masonry and framework for the future attachment of the finished joiner work, it is well for the plasterer to test the alinement of the walls and ceilings, or he may find that considerable "building-up" is necessary when he comes to apply the second, or floated, coat. Where this is necessary, the lathing should be stripped off, and the surfaces brought to a plane by the use of furring strips.

FIG. 6

In the case of dished, or concave, surfaces on stone or brick walls, the deficiency should be made good with cement

mortar before the first coat of plaster is applied. This course will insure a more durable wall, as there is little value in a mass of lime mortar unless it is applied in thin layers and thoroughly compacted.

Particular attention should be given to the spacing of the lathing. Although a simple matter in theory, in practice it will be found that unless much care has been taken in spacing the strips, many narrow insignificant slivers have been used for closers; these should be discarded and the panel stripped and relathed, otherwise much of the strength of the wall will be lost.

For three-coat work, which is the grade in general demand, the plaster grounds on brick or stone walls that are to be coated on a solid wall should be $\frac{5}{8}$ inch in thickness, and those for lathed surfaces $\frac{7}{8}$ inch. At no point should the surface of the solid wall or that of the lathing approach the face of the grounds nearer than the regulation thickness for the plaster, which will be about $\frac{5}{8}$ inch. The face of the masonry on stone or brick walls is more or less irregular, and grounds less than $\frac{5}{8}$ inch in thickness are of little value for attaching the finished woodwork.

32. Names of Coats.—Plaster is usually applied in three coats, although in some localities two is the customary number, the first coat being straightened and smoothed carefully to receive the finishing coat. This, however, is done in the cheaper kinds of plastering only. The first layer applied is called the *scratch coat;* the second, the *brown*, or *floated coat;* and the third, the *skim*, *white*, or *finishing coat*. On brickwork and stonework, and also on terra-cotta partitions, etc., the scratch coat is usually omitted.

33. Scratch Coat.—The method of applying the scratch coat is illustrated in Fig. 6. The coarse stuff is taken in batches from the *souring pile*, tempered with clean water to the proper degree of firmness, shoveled into hods, and carried to the rooms and deposited on the mortar boards, shown on the floor, ready for application by the plasterers. A quantity of mortar is placed on the wooden hand board, or **hawk**, *g*,

by means of the trowel *h*. Slices of the mortar are then cut from the hawk and spread firmly and evenly over the surface of the lathing or the naked wall, as the case may be. The mortar should have a dough-like consistency, should be tough and hold well together, and should be soft enough to be readily pressed in between the laths, so that it will bulge out behind and form the clinch, or key. The thickness of the layer should be fully $\frac{1}{4}$ inch, so that when set it will furnish a rigid surface to work over. In cheap work, this layer is often only a skim coat, and it is not unusual to see the rough-sawn grain of the lath protruding through the mortar. After the coat has somewhat hardened—which requires from 2 to 4 days after application—it is scratched over diagonally with wooden comb-like blades *i*; from this fact the first layer is often called the **scratch coat.** The scratches, or grooves, thus formed in the mortar fulfil the same function as the spaces between the lath—to allow a good key for the subsequent layers. The first coat should be nearly dry before putting on the next; if too dry, the surface should be slightly dampened with a sprinkler or a brush, before applying the second coat.

If the walls are partly masonry and partly wood, the first coat is applied only to the lath—unless the stone or brick walls are furred and lathed also. When the scratch coat is dry, the second coat is spread over this and the masonry. If plastering is applied directly to brick or stone, the joints in the latter should be raked out, so as to form a better clinch for the mortar. The walls should also be free from dust and be slightly dampened before putting on the mortar.

34. Brown Coat.—The second coat, which consists of fine stuff to which a little hair is sometimes added, is applied from $\frac{1}{4}$ to $\frac{3}{8}$ inch thick when the scratch coat has become sufficiently firm to resist pressure. The second layer is frequently called the **floated coat,** because its surface is worked by means of board-shaped trowels, called floats; it is also known as the **straightening coat,** since all the wall surfaces are straightened and made true by its application.

On walls, if the grounds are set true and the surfaces are not too large, the plastering can usually be brought to a true plane without much difficulty. On the ceilings, however, there is nothing to guide the plasterer, and in many cases, if great care is not taken, the ceilings have a rolling surface, as may be seen at the edges.

In order to get perfectly level walls and ceilings, especially in cases where the grounds are insufficient, resort is had to what is known as *screeding*. Screeds are plaster bands 5 or 6 inches in width formed on the surface to be floated. The surfaces adjacent to the angles are carefully plumbed up from the plaster grounds *e*, Fig. 7, but are kept back about $\frac{1}{8}$ inch from the face, to allow for the finishing coat; vertical screeds *f* are formed by means of the straightedge *g*. Similar screeds *h* are formed along the ceiling angles; these screeds are made straight, and coincide with those at the opposite angles. Intermediate horizontal or vertical screeds, as *i* and *j*, are then formed between the screeds adjacent to the ceiling and the plaster grounds, as preferred by the plasterer. These are usually placed from 4 to 8 feet apart, and are gauged to line by means of the straightedge. The screeds thus form a system of framing that has been reduced to a true plane. The panels may then be filled in flush, in line with the screeds, and firmly rubbed down with the two-handed float, or derby, *k*. The surface is then worked over with a wooden hand float, the coat being firmly compacted by incessant rubbing; should the coat become dry during the process, it is moistened by applying water with a wide brush. A close, firm

Fig. 7

layer can be obtained only by the thorough laborious operation of pressing and rubbing the particles of the mortar together; and herein lies the secret of strong, durable work —plenty of "elbow grease." In order to form a rough base for the subsequent coat, the surface is scratched over with a broom. The ceiling surfaces are treated in a similar manner, and the screeds are carefully leveled so as to obtain true and level planes.

The space between the plaster grounds and the floor is usually finished with a scratch and a brown coat of plaster, so as to prevent air-currents from entering the room through the spaces between the furring strips. In cheap work this filling is omitted, the spaces being covered with a finished wooden base.

35. Green Work.—Very often the brown coat is put on immediately after the scratch coat without allowing time for the latter to dry; this is known as **green work.** In such a case, the first coat is made very rich, while the brown coat contains a large proportion of sand and is worked into the first so as to really form but one coat. While it saves time, this practice cannot be commended. A much better plan is to allow the scratch coat to dry before the brown coat is put on, although more labor and lime are thus required. Another objection to green work is that the excess of moisture causes the laths to swell badly, which, in drying, shrink and produce cracks in the plastering. Nearly all lime plastering is green work unless otherwise specified.

FIG. 8

36. Finishing Coat.—Sometimes the finishing coat is omitted in cheap work, when the walls are to be papered, the brown coat being made as

smooth as possible. This method is not very good, as the rough plaster is likely to mar the smoothness of the paper.

There are several kinds of finishing coats, such as *troweled stucco*, *rough sand finish*, *hard-finish white coat*, etc.

In all cases, the material is applied to the wall in the form of a stiff paste by means of the steel trowel *a*, as shown in Fig. 8, and is spread uniformly over the surface to a thickness of about $\frac{1}{8}$ inch.

37. Troweled stucco, which consists of fine stuff and very fine white sand, to which a little white hair may be added, is thoroughly polished to a glazed finish with the trowel *a'*, Fig. 8, the surface being kept moist by water applied with the brush *b*. This is frequently called the *skim* coat.

38. Rough sand finish may be produced on the stucco by covering the hand float with a piece of carpet or felt, which will cause the sand to rise and present the characteristic sandpaper surface. It may also be made by using more and coarser sand with the lime putty.

39. Hard-finished white coat consists of gauged stuff smoothed and polished with the steel trowel. As this material sets rapidly, care should be taken to observe that the second coat is well dried; otherwise, the unequal shrinkage will cause hair cracks to occur all over the finishing coat. Marble dust is frequently mixed with the gauged stuff to give greater hardness and a surface susceptible of higher polish, about equal quantities of marble dust and plaster of Paris being used.

HARD WALL PLASTERS

40. While, by the use of the best materials and proper care in preparing and applying them, a good wall may be obtained with lime plaster, yet there are so many uncertainties about it that numerous substitutes have been brought into use, which have proved valuable and efficient. These are known under the general name of **hard wall plasters,** and may be divided into two classes: *natural-cement plasters* and *chemical*, or *patent*, *plasters*.

45. Advantages of Hard Plasters.—Hard plasters have many points of superiority over lime plaster, which more than balance their extra cost and which will in time probably result in their almost exclusive use. Being machined-mixed, the plaster made from them is uniform in quality and strength and has unvarying proportions of the constituents, while two batches of lime plaster may differ a great deal in this respect. They are also much harder and more tenacious, and resist fire and water better than lime, and the small quantity of water used in mixing enables them to dry much more rapidly. They are not injured by frost after they have begun to set, but should be protected from it for the first 36 hours after being put on the walls. Heat and moisture are not readily transmitted by hard plasters, and being more dense than lime plaster, they do not absorb noxious gases nor permit the entrance of disease germs.

ORNAMENTAL PLASTERING

46. Cornices.—As a rule, cornices are molded before the finishing coat is put on, the operation of making them being about as follows: Longitudinal strips are first attached to the wall, as at *b*, *b*, Fig. 9, on which a templet guide shown at *a* is run. Sometimes a strip is also attached to the ceiling, but more often the ceiling guide is merely a line. The coarse stuff is made to conform to the approximate profile with a *muffled templet*, that is, by forming a layer of plaster of Paris about $\frac{1}{8}$ inch in thickness along the edge of the templet; or an extended profile can be cut out of zinc and temporarily attached to the correct templet. The templet is placed in position and pushed along the angle of the wall, as indicated in Fig. 9. When the coarse stuff has been correctly profiled, the surface is coated with gauged stuff and carefully worked over with the correct templet until an exact and perfect finish is obtained. The internal and external angles cannot be finished by means of the templets, but must be carefully molded and mitered by hand, using jointing tools, such as shown in Fig. 5. Some plasterers prefer to push the

templet with the left hand instead of with the right, as shown in the figure, so that they can handle the trowel with the

FIG 9

right hand when applying the stuff and make up any deficiency; therefore, the templets should be made to suit the direction in which they are intended to be driven.

47. Sometimes the clinch, or key, is reinforced and the plaster held more firmly in place by using projecting spikes or large nails, which are driven into the wall or ceiling before the mortar is applied. This method is shown in Fig. 10, in which *a* shows the mortar; *b*, *b*, the laths; *c*, *c*, the spikes; and *d*, the finished surface.

FIG 10

When the cornice projects considerably, the angle should be blocked, or cradled, and lathed, to reduce the quantity of plaster required, as there should be no thickness of plaster much over 2 inches. This method is represented in Fig. 11, in which *a* shows one of the blocks, which are nailed to the floor joists; *b*, *b*, the laths; *c*, the cornice; and *d*, a dentil course. If the cornice is to be ornamented as at *d*, a recess is left in the plastering to receive the pieces to be inserted, which are formed separately and then stuck in place by liquid plaster.

FIG. 11

When there is much ornament, it is cheaper to cast the cornice of plaster of Paris in sections 2 feet or more long; these may be attached to the wall by thin plaster. Careful work is required to make the molded pieces come together or match properly.

48. Centerpieces.—Centerpieces that consist only of plain circular moldings are formed in the same manner as cornices, except that the mold, or templet, is so fastened as to swing around the center of the ornament.

When decorated centerpieces are used, they are usually cast in a mold and stuck on the ceilings by liquid plaster of Paris. Nearly all kinds of ornamental plastering, such as paneled ceilings, bas-reliefs, imitations of foliage, etc., may be easily cast of plaster of Paris and made to serve the purpose as well as more costly decorations.

PLASTER ORNAMENTS AND SCAGLIÓLA

49. Plaster ornaments are now less extensively used than formerly. They are usually made of plaster of Paris and lime, but for cast work, only the former is used.

A light and strong material used to some extent for ornamental work is made by applying a thin layer of plaster of Paris to pieces of stretched canvas, forming a kind of board. If casts are to be made, the plaster is poured into the molds, and while it is still soft, the canvas backing is pressed lightly into it.

Another material, known as *carton pierre* and by various other names, is also much used for ornamental work. It is composed of whiting (ground chalk), paper pulp, hemp fiber, etc. mixed with glue, which is pressed into molds, backed with strong paper, and dried. Ornaments made of this substance are much tougher and lighter than if cast in plaster of Paris, and are considerably used for interior decorations and also for outside work; for the latter use they should be painted.

50. Scaglióla is a material applied to columns, walls, etc. to imitate marble. The first, or ground, coat consists of lime mortar having a large proportion of hair mixed with it. This mortar is applied in the usual way and allowed to become thoroughly dry. Another coat is then applied, composed of Keene's cement, or plaster of Paris mixed with glue, or gelatine, to make it more dense and compact, and to retard the setting. Various coloring matters are also added to produce the required effect. The second coat is sometimes put on with a brush, a great many applications being necessary to properly blend the colors. To impart to the work the requisite polish, similar to marble, the workman rubs the surface, when it is hard, with pumice stone, then polishes it successively with tripoli, pulverized charcoal, and a piece of soft cloth, and finishes with oil. When well made and polished, scaglióla can hardly be distinguished from marble. It is unsuitable for exterior decoration, but

for interior work is nearly as durable as good stone, and in Europe there are columns made of it that are hundreds of years old.

51. Artificial Marble.—There is now on the market an artificial marble composed principally of Keene's cement. This marble can be made very strong, and has the advantage over natural marble in that it is lighter and can be obtained in larger pieces without any wax filling. It can be used for columns, balustrades, wainscoting, store counters, bathroom finish, and innumerable other purposes. This artificial marble is made into slabs, columns, or any desired shape, and is cemented into place by Keene's cement.

The most beautiful marble and onyx can be very closely imitated at a reasonable cost. Fig. 12 illustrates some styles, or colors, of artificial marble made by the American Art Marble Company, of Philadelphia. At (*a*) is shown pavonazza; at (*b*), red Numidian; at (*c*), dark sienna; and at (*d*), Alps green.

A very durable imitation of marble is also made from glass. This material is stronger and more dense than marble itself, and is useful around toilet rooms and places where cleanliness is to be desired. On account of its nonporous surface, it is particularly suitable for sanitary use. It may be had in various colors, although usually made pure white.

STUCCO

52. The term **stucco** was first used by the early Italian artificers to define a superior grade of plaster compounded by them; and their skilful manipulation of the material has never been excelled. From the fact that by using stucco the appearance of dignity and stateliness on an otherwise mean and poverty-stricken structure could be acquired at a very low cost, it was for many centuries very extensively used. Many of the so-called stone and marble palaces will be found, on examination, to be only brick shells coated or veneered with stucco, but so well treated and handled as to

(a)

15μ

(c)

(b)

(d)

§ 38

present a very superior surface, being scarcely discernible from the material that it is made to imitate. At the present time, stucco is used only to a limited extent and only for a cheap class of structures.

To secure the best results in stucco work, a good cement mortar is requisite, as lime mortar, which was formerly used, does not prove very durable. For use on brickwork, the plaster should be made of Portland cement and clean sharp sand mixed in the proportion of one part of cement to three parts of sand, with sufficient water to make a stiff paste. Before adding the water, the mortar joints in the brickwork should be raked out, so as to form a good clinch for the covering, and the surface of the wall should be well dampened to prevent the bricks from too quickly absorbing the water in the mortar. Resort is sometimes had to screeding, to make the surface true and uniform. When the mortar is put on in more than one layer, the previously laid coat should not be allowed to dry before the next one is applied, as the coats will not adhere well and will probably scale off. Before the finishing coat has hardened, it may be marked with lines to indicate the joints in ashlar. The mortar may be colored to represent stone by the use of mineral colors, such as Venetian red or the ochers; while if a light color is desired, it may be obtained by mixing a small quantity of lime with the cement.

53. Rough cast is a kind of coarse plastering that is considerably used in Canada and other places with cold climates as a substitute for siding and shingles. It costs less, is more durable and much warmer than wood, and resists fire to a considerable extent. If a frame building is to be covered, it should first be stiffened by having the partitions built and the outside sheathing put on. Laths are then nailed on the sheathing, being laid diagonally and about $1\frac{1}{2}$ inches apart, breaking joints about every 18 inches. Over this course is laid another, the laths sloping in the opposite direction, with similar spacing and broken joints. This thickness of laths should be put on with great care, to

insure the permanence of the work. If wire or expanded-metal lathing is used, there will be considerable gain in strength and fireproof qualities.

The scratch coat should be made of rich lime mortar having a large proportion of hair, and should be mixed about 4 days before it is applied. This coat should be thoroughly laid on and well pressed between the laths in order to form a good clinch, and its surface should be well scratched so as to form a key for the second coat. It should be allowed to dry thoroughly, but its surface should be sprinkled before applying the second coat, which has the same composition as the first. The second layer should be kept moist and soft until the finishing coat is put on. The latter is called the **dash**, and is made of clean fine gravel and lime stirred up with water until the mass has a semifluid consistency. Various coloring matters may be added if required. A black mortar may be obtained by mixing 5 pounds of lampblack with the dash; a buff, by using a like weight of copperas. The dash is then thrown on the plastered walls with a wooden float about 5 or 6 inches square. Before the dash dries, it is gone over with a brush dipped in the liquid, to give the face a uniform appearance.

For 100 square yards applied as described, there will be needed 1,800 laths, 16 pounds of $1\frac{1}{4}$-inch lath nails, 12 bushels of lime, $1\frac{1}{2}$ barrels of hair, $1\frac{3}{4}$ cubic yards of sand, and $\frac{3}{4}$ cubic yard of washed gravel. For the dash, a quarter barrel of lime putty should be mixed with every barrel of washed gravel.

54. Staff.—Although staff has been used for a long period in Europe, it was first brought into extensive use in the United States in 1891–93, when it was employed for constructing the World's Fair buildings at Chicago. As used at Chicago, it is made about as follows: The ingredients are plaster of Paris, water, and hemp fiber, the latter being used to bind and strengthen the cast. A suitable mold having been made, the hemp is cut into 6- or 8-inch lengths, bunched loosely, dipped in the liquid, and placed in the mold in layers until the mold is full, each handful being interwoven with

those previously laid and pressed in so that the cast will be compact and uniform throughout. When the mold is filled, the surface is smoothed over by hand, and when thoroughly set, the cast is removed. In warm weather, about 36 hours is necessary for thorough drying, but in cold weather, more time is required and the cast should not be subjected to frost before it is dry.

Staff may be nailed directly to the rough boarding of a wooden building. If it is to be applied to a new brick structure, however, furring strips should be inserted in the brickwork.

This material, while cheap and satisfactory for temporary structures, does not seem well adapted for permanent buildings, as it deteriorates in course of time in the Northern States owing to the rapid changes of temperature. Where the temperature is more uniform, staff has proved to be a very durable material.

WHITEWASHING

55. Whitewashing being often included in the plasterer's specifications, a brief mention of it is desirable. Common whitewash is made by slaking fresh lime and adding enough water to make a thin paste. It is applied to walls and other surfaces with a brush. Whitewash will adhere best to rough and porous surfaces. For good work, two coats should be put on. By using 2 pounds of sulphate of zinc and 1 pound of salt to each ½ bushel of lime, the whitewash will be rendered much harder and will be prevented from cracking. Its durability, especially for outside work, may be increased by mixing 1 pint of linseed oil with each 2 gallons of whitewash.

Whitewash is a very useful agent for preventing decay of wood, and is valuable from a sanitary point of view in buildings of wood, stone, or brick.

INSPECTION OF WORK

56. Lathing.—Before the lathing is begun, the inspector should see that the furring and grounds are properly placed and are plumb and square; also, that the angles of chimneys and other projections are right angles. If the lathing is of wood, he should see that the laths are free from bark and loose knots, and that they are put on with proper spacing, well nailed, with no springy ends, and end joints broken at least every 18 inches. Over door and window openings, the laths should extend to the next stud on either side of the frame. As far as possible, the lathing should run the same way, as cracks are liable to occur in the plastering at places where the direction of the lathing is changed. The junction of brick and wooden walls, as well as lintels and unfurred timbers, should be covered with pieces of metal lath, as already mentioned.

57. Plastering.—If lime plaster is to be used, the inspector should see that the lime is fresh and without unburned lumps, and should allow none to be used that has begun to slake. The sand used should be sharp and free from earthy matter. The hair should not be added until the lime has become thoroughly slaked and cooled, and the mortar should be made at least a week before use. It is well to become acquainted with the appearance of good mortar, so as to be able to judge its quality.

Before beginning to plaster, the openings in the building should be closed with boards or muslin. In winter, a building in which plastering is to be done must be heated. Lime mortar, especially, is rendered worthless if frozen and then thawed; hard plasters, also, should not be permitted to freeze. The inspector should see that the first coat is well clinched between the laths, and is thoroughly dry before the second coat is put on. If the scratch coat is to be laid on brick, the walls should be well wetted before applying the mortar. Special care should be taken with the brown coat, as the appearance of the finished work depends to a great

extent on good workmanship in applying this coat. Its surfaces should be plane, with straight and square angles and a level ceiling. If hard plasters are used, the directions furnished by the makers in regard to mixing sand, etc. (if not obtained already mixed) should be carefully followed. Plaster that has partially set before use should be rejected.

MEASUREMENT OF WORK

58. Lathing is figured by the square yard and is usually included with the plastering, although in rural districts the laths are often put on by the carpenter. Plain plastering, such as that on walls and ceilings, is always measured by the square yard. Provision in regard to deduction for openings should be made in the contract, for unless this is agreed on, the custom of the locality will govern. In some parts of the country, one-half the area of openings is deducted; and elsewhere, no allowance at all is made for openings unless they are very large.

Where the work is difficult to put on, or where there are many angles, as in closets, the under side of stairs, etc., the price per yard is usually more than for broad unbroken surfaces. This is also the case when staging is required, and when the surfaces are other than plane. Ornamental work, of course, costs much more than plain; cornices, moldings, etc. are usually measured by the lineal foot, with extra allowance for corners.

TILING

59. The method of manufacturing tiles for floors, wainscots, etc. is similar to that employed for making terra cotta, but as these uses of tiles are in the nature of finishing processes, analogous to plastering on walls, the subject is considered in this Section.

60. Tiles are used very extensively for flooring aisles and passages in churches and office buildings, the floors of waiting rooms in railway stations, and also for vestibules, bathroom floors, hearths, borders, and backs of fireplaces in dwellings. Very artistic effects may be produced by the use of different colors and shapes; and for wainscots, by the use of the great variety of plain and decorated tiles. Tiles are of every color, and are made as large as 6 inches square, but it is not recommended that pieces of this size be used for flooring, as they are likely to break or become loose unless very carefully laid.

61. The art of laying mosaic floors was known to the Romans, by whom the component parts were termed **tesseræ,** from the word meaning *tesselated*, or checkered. These consisted of small pieces of hard material of various colors bedded one by one in a layer of cement, each piece being leveled with the others; and on the completion of the work any irregularities were corrected by rubbing the whole to a plane surface.

The modern tile floor is composed of pieces cut by dies. The pieces are thus uniform in size and fit closely together, having an almost imperceptible joint. As a guide in setting, a colored drawing of the intended design is usually made. The full-sized pattern is laid out on a perfectly level cement floor, on which the tesseræ are placed, face downwards, the workmen being guided in the arrangement of colors, etc. by the drawing. The pieces are afterwards joined together

by a layer of cement applied to the back, or upper surface, and in this way they can be formed into slabs of convenient size, which, when the cement has hardened, are ready for use, and can be easily laid either as centerpieces, borders, or pavements.

62. Tiles may be laid directly on the concrete of fireproof floors. When the floor is framed with wooden beams, however, the foundation course should be of bricks set edgewise on short pieces of boards that are laid on strips nailed to the sides of the beams. In order to save material, the bricks are sometimes laid flat. The average thickness of the tiles is $\frac{1}{2}$ inch, although they often run $\frac{5}{8}$ inch, so that the top of the layer of bricks should be $\frac{3}{4}$ inch below the finished floor. The tops of the beams should stand in the same relation to the tiling that they would to the top of a wooden floor, in order to avoid differences in level at the junction of the wooden and tile floors. In the case of a single wooden floor, the distance will be usually $\frac{7}{8}$ inch, and in a double floor, $1\frac{3}{4}$ inches.

After the bricks are laid, the brick surface should be swept clean and then well dampened. The tiles should also be soaked in water for some time before they are used. If this precaution is not taken, the bricks or tiles will absorb water from the thin layer of cement between them and make it powdery and useless. Only the best Portland cement should be used. The cement should be mixed rather thin and without sand.

63. When the tiles are laid with a centerpiece, the pattern should be commenced at the center, the position of which should be accurately ascertained by previous measurement. Straightedged strips of board should be put down as guides for each day's work, not only for regulating the lines of the pattern, but also for securing a uniform surface. This is done by first setting the strips carefully, and then laying the tiles by the aid of a straightedge resting on the strips. Each tile is set on a bed of cement spread for it, and beaten down to the proper level with the wooden handle of a

trowel. When a sufficient number of tiles has been laid, the joints may be grouted with liquid cement, which should, however, be immediately wiped off the surface of the tiles, since it is difficult to remove when dry.

If the cement used is good, the tiles cannot, after a few days, be removed without breaking, so that too much care cannot be exercised in placing them properly at first. When the pattern reaches the edges, it is usually necessary to cut many of the tiles. This can be done by soaking them well in water, and then scoring a line with a sharp chisel, where the separation is to be made; by placing the chisel exactly on the line, a sharp blow will effect the separation. Wide chisels should be used, and the tiles must be well soaked, for unless this is done they are likely to fly into fragments.

After the tiles are laid, the floor is covered with sawdust an inch or so deep, and planks are then laid over this, to protect the tiling until it has become set. If a baseboard or a wainscot, whether of wood or stone, is required, it is then fitted down on the tiling.

64. If marble tiles are used in place of terra cotta, the laying should be done in the same way, that is, on bricks set on edge. The marble tiles are considerably thicker than the clay tiles, being generally from $\frac{7}{8}$ to $1\frac{1}{4}$ inches, and the guide strips should be set accordingly. The under side of the marble is usually quite rough; therefore, the laying is easier than that of clay tiles. Mortar made of equal parts of cement, lime, and sand may be used.

65. Fig. 13 is an example of a bathroom or lavatory wall faced with white tiling. A dado, or wainscoting, is emphasized half way up the wall by the insertion of a course of colored ornamental tiling, done in gold and capped with a band mold. At the floor, a special plinth, or base, course is inserted. An ornamental frieze is put in near the ceiling line immediately under the angle cove, and makes a suitable and effective framing for this apartment. Specially designed tiles form the door frame, and can be selected from manufacturers' catalogs. It will be noticed that special curved

159 FIG 13 § 58

(a)

(b)

159 (c) (d) [illegible]

FIG. 14

159 Fig

159 FIG 18 ⁋ 5.

FIG. 20

159 FIG. 21 § 38

tiles are used at the junction of the floor with the wall and also between the wall and the ceiling. The purpose of these curved tiles is to do away with angles where dust and dirt may accumulate and which are hard to keep clean.

The designer in laying out such work must remember that it is always cheaper to select stock tiles than to have them made special. He will also find that he will be able to get tiles kept in stock at much shorter notice than those that have to be made especially for one job.

This design possesses the charm of cleanliness, and makes the room bright and attractive. While the general constructive features shown in Fig. 13 should be observed in all rooms of this character, sufficient distinction can be obtained by the selection of appropriate ornamental designs. Without decoration, a tiled wall of this kind makes an excellent and sanitary finish for walls and ceilings in surgical wards of hospitals.

66. The four floor designs shown in Fig. 14 well illustrate the scope of this material and the elasticity possible in design. The tiles in two of these examples are square, and in the others they are hexagonal. The nature of these units, if uncut, compels conventional designs. At (*a*) is shown a design with a rich all-over pattern for the field, and an interlaced circle with emphasized center for the border. At (*b*) is shown a design where the center is much more open in treatment, and the border is a simple meander. The color scheme in this pattern is much more quiet than that of (*a*). The fields in (*c*) and (*d*) are much more open in treatment than in (*a*) and (*b*), and the borders are more prominent. With a number of different colors, the design and color schemes possible with these tiles are almost infinite. It will be noticed that while (*a*) and (*b*) are made of square tiles, (*c*) and (*d*) are laid with tiles having six sides.

67. Figs. 15 and 16 are examples of much more elaborate designs where tiles of irregular shape are necessary in order to carry out portions of the design, as, for example, in the beaks of the peacocks, the leaves of the flowers in the border,

even if the plant were permanent it would often be idle on account of no building being done, it is sometimes more economical to make brick by hand than to put in brick-manufacturing machinery.

When making brick by hand, the clay is worked in a circular pit, usually about 2 feet 6 inches deep and 15 feet in diameter. In the center of this pit is a brick or stone pier with a vertical pin fastened in its center. Pivoted to this pin is a horizontal shaft with a wheel, and this wheel rests on the clay that has been thrown into the pit. Water is added to the clay and the mixture is churned by the wheel, which is turned, somewhat like a wagon wheel, by a horse that is hitched to the far end of the shaft and walks around and around. When the clay becomes soft, it is taken to the molding table and pressed into the molds by hand.

The molds, which have neither top nor bottom, are usually made of wrought iron and wood or cast iron or brass. When it is desired to make an indentation, called a *frog*, or *kick*, in one side of the brick, so as to give a better bond to the mortar, the mold is set on a *stock board*, or *bottom*, made to fit it and having a projection the shape of the desired frog. The top of the mold is always struck flush, with a steel or wooden straightedge. When laying a brick with a frog in one side, the frog side is placed upwards. In wire-cut machine brick, of course, there can be no frogs, but frogs are often made even in both sides of pressed brick.

Before filling, the brick molds are either dipped in water (called *slop molding*) or in sand (called *dry molding*) to prevent the clay from adhering to the mold. The sand-molding process gives cleaner and sharper brick than the slop molding. After the brick are shaped in the mold, they are laid in the sun or in a dry house for 3 or 4 days, after which they are stacked in kilns and fired.

MACHINE-MADE BRICK

3. Where many brick are made, the work is usually done by machinery, using one of three methods known as the *soft-mud*, the *stiff-mud*, and the *dry-clay process*.

4. Soft-Mud Process.—In the **soft-mud process,** the clay is thrown into a plank-lined pit, where it is soaked in water for 24 hours. The usual custom is to provide several pits, so that one pit may always contain clay that has been softened by the water and is ready for use while the other pits are being filled or the clay is in the process of softening. In some localities where the clay is somewhat wet in the clay bank, or where a lower grade of brick is being made, the clay is not wetted until it is placed in the machine.

From the softening pit, the clay is taken by a conveyer and dropped into a hopper, from the bottom of which it goes into one end of a trough. Down the axis of this trough runs a revolving shaft with knife blades along its length that are set at the same angle as the blades of a ship propeller. This shaft with its blades is known, in the machine trade, as a *screw conveyer* or a *worm*. This worm works the clay to the end of the trough farthest from the hopper. If the clay has not been soaked in the softening pits, it is wetted in the trough by means of a spray, which spreads the water evenly and thus prevents unequal wetting. The blades of the worm help to completely mix the clay and make it homogeneous. At the end of the trough is a plunger that works up and down and forces the clay into a wooden mold, which is divided into six compartments, each one being the size of a brick. The mold is taken out of the machine at each stroke of the plunger and a new one inserted, the brick being emptied out of the mold on a board and then taken to the drying yard where they are allowed to dry before being burned.

5. Stiff-Mud Process.—In the **stiff-mud process,** the clay is first thoroughly ground, and just enough water is added to make a stiff mud. After this mud is mixed and tempered in a *pug mill*, it is placed in a machine having a die the exact size of the brick required. The opening in this die is made the size of either the end or the side of a brick. The machine forces a continuous bar of clay through this die, and as it emerges it is automatically cut into bricks, which are then taken to the drying yard. The soft brick

are placed in rows in a yard covered by a rough shed, with open sides, where they are sun or air dried for 3 or 4 days. When properly dried and before burning, they resemble somewhat the "adobe" brick that were formerly used for constructing houses and are still employed in the southwestern part of the United States, and also in Mexico and Central America.

6. **Dry-Clay Process.**—The process often employed in the best work is the **dry-clay process.** In this method of manufacturing brick, the clay is used just as it comes from the bank, and is apparently perfectly dry. It contains, however, about from 7 to 10 per cent. of moisture. The clay is dug from its bed and stored in mounds, sometimes called *kerfs*, to allow the mass to disintegrate. It is usually kept in this manner for two or three winters, as frost seems to have a good effect on it, and brick made from clay thus weathered will not warp in the kiln. In England, the clay used for making the very best brick is frequently stored in cellars. After the clay has been stored for a sufficient length of time—although often, due to rush of business, it is not kept at all—it is forced through a perforated plate, called a *dry pan*, and is then screened. In some localities, it is necessary in making brick to mix several kinds of clay to get the best results. After screening, the clay is filled loosely into molds. These molds are of the same width and length as the brick, but are deeper than the required thickness of the brick. A plunger that exactly fits the mold is then forced in under heavy pressure and compresses the clay to the size of the brick desired. The brick are then removed to the kiln and fired.

Molded brick are made in the same way, the difference being that the box is made to give the shape of the brick required.

Whenever the term *pressed brick* is used, it should mean the brick made by the dry process. There are many so-called *dressed*, or *face*, *brick*, however, that are made by recompressing soft-mud brick.

BRICK BURNING

7. The brick, after drying, are built in a large mass, or kiln, containing from 100,000 to 300,000. *Eyes*, or flues, are left at the bottom as receptacles for fuel. The brick are laid loosely together in order to allow the heat to pass in and around them. When ready, the fire is started, slowly at first, but afterwards increased to an intense heat; and after burning for a period determined partly by the fuel used, but mainly by experience, the fires are allowed to die out gradually.

On opening a brick kiln after burning, the quality of the brick therein contained may be divided into four classes: (1) The extreme outside brick, which are burnt so little that they are almost worthless. (2) A layer inside of the first, in which the brick are underburned and soft; these are called *pale*, or *salmon*, *brick*, and are unfit for foundation or face work, but are used for filling in between stud partitions, and sometimes between harder brick in the inside of walls, although their use for this purpose is not recommended. (3) In the third layer of the mass forming the kiln, is found a class of brick well burned, hard, well shaped, and of a good red color; this kind of brick is good for any purpose. (4) The brick in the fourth, or inner, layer of the kiln, just above the flues, are overburnt, very hard, very brittle, and usually distorted, cracked, and even vitrified; they should not be used in any structure subject to shock, but are often employed for paving.

CLASSIFICATION OF BRICK

8. Common Brick.—The term **common brick** includes all those that are intended for structural, and not for ornamental purposes, and that require no special pains to be taken in their manufacture. There are three grades of common brick, termed, according to their position in the kiln, *arch*, or *hard*, *brick; red*, or *well-burned*, *brick;* and *soft*, or *salmon*, *brick.*

9. Pressed, or Face, Brick.—**Pressed brick,** also called **face brick,** are usually made by the dry-clay process, or else they are repressed brick. These brick are hard and smooth and have sharp corners, but as they cost more than common brick, they are seldom used except for facing walls built of cheaper grades of brick on the inside.

The special forms of pressed brick are called *molded*, *gauged*, *arch*, and *circle brick.* Molded and ornamental brick are now manufactured in a great variety of forms and patterns, so that cornices and moldings may be constructed entirely of brick. If an architect requires special patterns of molded brick to carry out designs, most of the larger companies manufacturing pressed brick will make the special shapes desired if drawings are furnished. These should be drawn to a large scale, and full-sized details should be given.

10. Stock Brick.—Hand-made brick intended for face work are called **stock brick,** and in manufacturing and burning them, greater care is taken than with common brick. Stock brick are used extensively for the outside facing of factories, machine shops, and the cheaper class of private dwellings. In the Eastern States, they are sometimes called *face brick.*

11. Arch and Circle Bricks.—**Arch brick** for circular or segmental doors and window openings in brickwork should be made in the form of a *truncated wedge*, that is, a wedge with the sharp end cut off. The walls of circular towers, bay windows, etc. are faced with the so-called **circle brick,** or brick molded to the shape of the circle desired. The radius of the bay or the tower should always be given when ordering the brick.

12. Firebrick.—The brick used for lining furnaces, lime kilns, fireplaces, and tall chimneys in manufactories are called **firebrick.** They should be free from cracks, of homogeneous composition and texture, uniform in size, of a regular shape, easily cut, and not fusible. They are usually somewhat larger than the ordinary building brick, and are made of fireclay, which is usually found in the coal measures. The best firebrick are hand molded.

13. Glazed and Enameled Brick.—Brick that are either glazed or enameled are used largely for lining water-closet and bathroom walls, the wainscoting of halls and staircases, and in many cases for the entire walls of stores and restaurants, hospitals, public waiting rooms, and markets, or wherever a non-absorbent surface that is clean and light is desired. Glazed and enameled brick can be used for the exterior of buildings as well as for the interior, as they will withstand the most severe changes of weather, reflect light, acquire no odor, are impervious to moisture, and are fireproof.

There are two kinds of enameled brick known to the trade; namely, **glazed brick** and **enameled brick.** Glazed brick are made by coating the unburned brick on the side on which it is to be glazed with a *slip*, and then putting on a coat of transparent glaze closely resembling glass. The slip, which gives the brick its white color, is a composition of ball clay, pulverized kaolin, flint, and feldspar.

In a genuine enameled brick, the enamel is fused directly into the brick without any intermediate coat, and the enamel in itself is opaque.

14. An enameled surface can be distinguished from one that is merely glazed by chipping off a piece of the brick. The enameled brick will show no line of demarcation between the body of the brick and the enamel, while the glazed brick will show a layer of slip between the glaze and the brick. Brick are enameled or glazed only on one face or on one face and one end.

True enameled brick cost more than glazed brick, as they are more difficult to manufacture; but, owing to the enamel being a part of the brick itself, an enameled brick will not chip or peel as readily as a glazed brick and is therefore more desirable.

15. The real enameled brick are made from a certain kind of clay that usually contains a considerable quantity of fireclay. The enamel is applied to the brick either before or after it is burned, the latter method producing the best brick.

For many years all the glazed and enameled brick were made in England, but there are now several factories in the United States. Many of the American manufacturers make the American standard size, which is $8\frac{1}{4}$ in. × 4 in. × $2\frac{1}{4}$ in., but some of them adhere to the English standard size, which is $8\frac{3}{4}$ in. × $4\frac{1}{4}$ in. × $2\frac{7}{8}$ in. However, the sizes of brick vary a great deal in different sections of the country.

16. Paving Brick.—**Paving brick** are usually made by the stiff-mud process, being repressed to give them better shape, and are composed of about three parts of shale clay to one part of fireclay. They are burned at a high temperature to the point of vitrification, that is, to a heat at which they begin to fuse. These brick have a high crushing strength and absorb very little moisture. They are used principally for paving driveways, and occasionally for paving flat roofs on fireproof buildings.

17. Sand, or Sand-Lime, Brick.—The composition of **sand brick** is usually 95 per cent. of sand and 5 per cent. of slaked lime. This mixture is forced into molds under a very high pressure, and the bricks are then heated with superheated steam. These bricks can be made in many colors by artificial means, and can thus be used to effect the most pronounced designs. Sand brick are now manufactured by many firms in the United States, some of which make a very good dense brick, while others make an inferior sandy article. One marked advantage in favor of the manufacturer of sand brick is that the brick do not have to be burned in a kiln and are therefore economical to make in a locality where fuel is scarce.

SIZE OF BRICK

18. There is no standard size of brick in America. The dimensions of brick vary with the locality and also with the maker. When ordering brick, a good plan is to specify that all brick shall be over a certain given size; otherwise it will be found that many more brick will be required for a job than were at first expected. Also, as brick are often laid at a certain price per thousand, the cost per cubic yard of

masonry will be increased if smaller brick than those figured on are used.

In the New England States, the average size of common brick is about $7\frac{3}{4}$ in. $\times$ $3\frac{3}{4}$ in. $\times$ $2\frac{1}{4}$ in.; New York and New Jersey brick will run about 8 in. $\times$ 4 in. $\times$ $2\frac{1}{2}$ in.; and the walls laid in them will run nominally 8, 12, 16, and 20 inches in thickness for 1, $1\frac{1}{2}$, 2, and $2\frac{1}{2}$ brick. Most of the western common brick measure $8\frac{1}{2}$ in. $\times$ $4\frac{1}{8}$ in. $\times$ $2\frac{1}{2}$ in., and the thickness of the walls measures about 9, 13, 18, and 22 inches for thicknesses of 1, $1\frac{1}{2}$, 2, and $2\frac{1}{2}$ brick. On the seacoast of some of the Southern States, the brick are made with a large percentage of sand, and will average 9 in. $\times$ $4\frac{1}{2}$ in. $\times$ 3 in.

Most manufacturers of pressed brick use molds of the same size; hence, pressed brick are more uniform in size. They are generally $8\frac{3}{8}$ in. $\times$ $4\frac{1}{8}$ in. $\times$ $2\frac{3}{8}$ in. Pressed brick are also made $1\frac{1}{2}$ inches thick. A form frequently used and known as Roman, or Pompeian, brick is 12 in. $\times$ 4 in. $\times$ $1\frac{1}{2}$ in. in size. In order that a good bond may be secured, pressed brick should be made of such size that two headers and a joint will equal one stretcher.

The weight of brick varies considerably with the material used in their manufacture and also with their size. Common brick will average about $4\frac{1}{2}$ pounds each, while pressed brick, owing to their greater density, will weigh about 5 pounds each.

STRENGTH AND QUALITY OF BRICK

19. All brick should be of uniform dimensions, free from cracks, pebbles, or pieces of lime, and should have sharp corners. The brick should be well burned, but not vitrified so that they become brittle. When two good bricks are struck together, they should emit a metallic ring. A good brick will not absorb over 10 per cent. of its weight of water if allowed to soak for 24 hours. Brick suitable for piers and foundations of heavy buildings should not break under a crushing load of less than 4,000 pounds per square inch.

The transverse strength of a brick is quite as important as the crushing strength. A good brick 8 inches long, 4 inches

wide, and 2½ inches thick, should not break under a center load of less than 1,600 pounds, the brick lying flat, supported at each end only, and having a clear span of 6 inches and a bearing at each end of 1 inch. A first-class brick will carry 2,250 pounds in the center and not break; such a brick has been tested to 9,700 pounds before breaking.

STRENGTH OF BRICKWORK

20. As a usual thing, the brickwork in walls is of ample strength to carry the loads imposed. The principal loads come on the piers and the arches. Of course, the strength varies, owing to different conditions that may exist; it is influenced by the strength of the bricks taken separately, the materials and quality of the mortar used in laying the brickwork, the workmanship and bond, and the age of the brickwork. As a rule, the strength of brickwork varies between one-tenth and fifteen one-hundredths of the strength of the brick itself, according to the kind of mortar used, the style of bond, etc. Two hundred pounds per square inch is a heavy safe load when cement mortar is used, and 150 pounds when lime mortar is used, although in certain cases much greater loads than these have been carried.

MEASUREMENT OF BRICKWORK

21. In making a contract for brickwork, when the payments depend on the number of brick and other materials in the wall, it should be distinctly stated, in order to avoid disputes, just how the work is to be measured and whether or not deductions are to be made for the openings and stonework.

The usual method of measuring is by the thousand brick as laid in the wall. Most contractors in estimating on the cost of brickwork take the entire superficial area of the wall in square feet, measuring it on the outside of the wall, and not on the inside. This is done to allow for the extra labor in laying up the angles. Sometimes, window and door openings are deducted, and sometimes not, according to the agreement. The brick are then computed as laying 7½ brick to

the square foot to a 4- or 4½-inch wall, 15 for an 8- or 9-inch wall, 22½ for a 12- or 13-inch wall, 30 for a 16-inch wall, and so on, adding 7½ brick per square foot for every additional thickness of 4-inch wall.

In figuring for pressed brick, when the walls are faced with them, the whole superficial area of the wall is taken, and the 4- and 4½-inch pressed-brick facing is estimated at 7½ brick to the superficial foot, to give the number of pressed brick in the wall. Deductions are then made for *all* openings, and when the reveal of a window is more than 4 inches, the additional depth is figured and added to the whole number of pressed brick.

The figures just given apply to the Eastern and New England States. In the West and South, the brick are larger, and give from one-quarter to one-third less per square foot in the wall than in the East, the price being regulated accordingly. In some parts of the West and South, two measurements are used. The first, or *kiln, count* represents the actual number of brick purchased and used, while the second, or *wall, measure* designates the number of brick in the wall, estimating 22½ brick to every superficial foot of 12-inch wall.

22. Among some builders, the custom prevails to reduce all brickwork to cubic feet and estimate in that way. As for example, a wall 24 feet long, 12 feet high, and 20 inches thick would contain 24 feet × 12 feet × 1 foot 8 inches = 480 cubic feet, at 22½ brick per cubic foot = 10,800 brick.

Unless openings are very wide and numerous, it is not customary to deduct them in estimating for common brickwork. Hollow walls and ordinary chimneys are usually measured as though they were solid brickwork.

When the contractor that has the contract for the brickwork sets the stone caps, sills, quoins, belt courses, etc., no deduction is usually made for the pressed brick that would take the place of the stonework. If, however, the stonework is furnished and set by another contractor, an allowance is often made for the face brick displaced by the stone.

BRICKLAYING

SOLID WALLS

JOINTS IN BRICKWORK

23. Importance of Mortar.—In laying brick, it is customary to bed them in mortar. The mortar serves several purposes; it has the effect of making the wall waterproof and air-proof under ordinary conditions. Of course, an ordinary brick wall is never absolutely impervious to water or air, but mortar joints prevent rain or wind from entering a house in such large quantities as it would through a wall laid up without mortar, or *dry*, as it is called. Another advantage in using mortar in the joints of brickwork is that a wall is made one solid mass, which of course increases its strength and stability. A consideration that is often overlooked, although of importance, is that mortar gives a certain amount of elasticity to the wall. Lime mortar is more elastic than brick, and thus by having a light bed of mortar between each course, many brick are prevented from cracking due to settlement or other causes.

24. Meaning of Brickwork.—By the term *brickwork* is meant not only the brick but also the mortar in the joints. It can readily be seen that the strength of brickwork cannot be dependent on the strength of the brick alone. Other factors influence this, such as the strength of the mortar and the method of laying up and bonding the brick. Therefore, the value of a good brick, so far as strength is concerned, may be decreased by the use of inferior mortar or by being laid by a bricklayer that does not understand his trade.

25. Size of Mortar Joints.—In laying up a wall, sufficient mortar should be used to fill all voids. Since lime

mortar, which is the kind often used in constructing houses, is not so strong as the brick, it is expedient that little more mortar than just sufficient to fill all voids should be used. Another consideration is that thick joints in brickwork present an unsightly appearance. In laying brick, a layer of mortar is first spread over the preceding course; then, each brick is laid in place and tapped with a bricklayer's trowel until sufficient mortar is squeezed out to make a joint of the required thickness. If the brick is made with a frog on one side, it is laid with the frog side up. To force a brick down until it touches the brick beneath it is not good practice, as the joints become so thin that they lose much of their strength.

Of course, the more regular the surface of the bricks, the closer they can be laid and the smaller will be the joints. With ordinary brickwork, the joints should not average more than $\frac{1}{4}$ inch in thickness. Suppose that the height of eight courses of brick as laid in a wall were $20\frac{1}{2}$ inches, and that each brick measured $2\frac{3}{8}$ inches in height; then, eight brick without any mortar should measure 19 inches, and the total thickness of mortar in the eight courses would be $20\frac{1}{2} - 19 = 1\frac{1}{2}$ inches. Therefore, each joint would average $\frac{3}{16}$ inch, which is less than the usual maximum allowable average joint in ordinary work. In pressed-brick work, however, the joints can be made smaller, probably $\frac{1}{8}$ to $\frac{3}{16}$ inch being about the usual thickness, because the brick are smoother and have no irregular projections.

26. Method of Laying Brick.—In laying brick, it is customary to lay the two outside courses first. As shown in Fig. 1, a trowel with mortar on it is held over the wall and moved in the direction of the arrow, at the same time being tilted so as to allow the mortar to slide off. This motion has a tendency to distribute the mortar along the wall. The mortar is then still further spread with the point of the trowel, which, by a vibrating movement of the hand, causes the mortar to form in little ridges. A brick is then placed on the wall and shoved into place, as shown in Fig. 2. This

operation has a tendency to squeeze the excess mortar out of the joint between the bricks, as shown in Fig. 3. The brick is, if necessary, then tapped down with the handle of the

FIG. 1

trowel, and all the excess of mortar thus squeezed out at the joint is then removed with the trowel, as shown in Fig. 3, by scraping it along in the direction indicated by the arrow. This extra mortar, which sticks to the trowel, is then scraped

FIG. 2

off against the edge of the brick to fill the vertical joint between it and the next brick to be laid, as shown in Fig. 4.

After the two outside courses have been laid, the middle courses are put in; all the *bats*, or broken brick, are used

here, as they will not be seen. A mortar bed is laid the same as for the outside courses, and the brick are slid and tapped down into it. The vertical joints are usually filled

FIG. 3

by picking up a little mortar on the trowel and forcefully throwing it down on the joint. The brick in the middle of a wall are usually laid farther apart than those on the outside, thus allowing the vertical joints to be filled as described.

FIG. 4

27. Laying Pressed Brick.—Pressed brick are usually laid in a better quality of mortar than that used for common brickwork. The sand used in the mortar is usually finer, so as to enable the joints between the brick to be made thinner,

and the mortar is often colored with mortar stains. In laying enameled brick in bathrooms and similar places, the joints are usually kept down to ⅛ inch. Pressed-brick work is often *striped;* that is, the joints are painted with a brush guided by a straightedge, the color of the paint employed being in contrast with the remainder of the work. This is called *ruled work.*

28. Finishing Brickwork Joints.—When brick walls are to be furred and plastered or are otherwise protected from exposure, the joints between the brick are merely smoothed off flush with a trowel. However, if the face of the wall is exposed, the joints are *struck*, as shown in Fig. 5 (*a*), where *a* shows the mortar joint and *b*, *b* the brick in the wall. In striking a joint like this, the point of the trowel, which is held obliquely, is used. This method makes the better job for outside work, as the water will not lodge in the joint and soak into the mortar, as would be the case if the joint were struck in the manner shown at (*b*). The second form, however, is easier to make.

(b)

Fig. 5

POINTING BRICKWORK

29. Pointing consists in scraping out the old mortar in the outer joints to the depth of at least ½ inch and then filling them with fresh mortar, which is well worked in with a trowel. The object of pointing is to prevent access of moisture to the interior of the joint.

In many cases, both old and new work need to be repointed after laying. In new work, however, if attention has been paid to laying the brick properly, with good ruled joints for face brick and neatly struck joints for common brick, "pointing up" may not be necessary; in fact, if the brick have been laid according to the usual specifications, it would be entirely

unnecessary. But when new work has been poorly laid or where old work requires renovating, pointing is often resorted to. If it is intended to point up new work, the raking out should be done with a piece of hardwood while the work is in progress; old work will have to be raked with an iron raker. After raking, the joints should be well swept with a stiff broom. In hot dry weather the wall should be kept wet while the pointing is being done.

For mortar, Portland cement mixed with about an equal quantity of clean fine sharp sand is preferable, but if cement cannot be obtained, the best quality of ground lime may be used. The whole quantity required for the job should be made up at one time if lime is used, and should be kept moist by placing it in a damp place protected from the sun and wind. Before using, the mixture should be beaten to proper consistency with a wooden or iron beater.

30. Tuck pointing is done by first filling the joint flush with brick-colored mortar, and then cutting a narrow groove along the middle of the joint; putty paste of the desired color is then laid in this groove in such manner as to form a narrow ridge, the edges of which are trimmed so as to be parallel. This method gives the appearance of close joints, and disguises any irregularities in the work. In *bastard tuck pointing* the ridge is wider, and is formed by a jointer having a **V** or **C** section drawn along a straightedge.

31. Bead pointing and **key pointing** differ from each other in that the first is made by a *jointer* having a semicircular section that produces a ridge of the same shape, and the second is formed by drawing along the joint a *key* having a circular form, pressing it in firmly so as to compact the mortar.

LAYING BRICK IN SEVERE WEATHER

32. When brick are dry, they absorb moisture from the mortar in which they are laid and thus prevent the mortar from attaining its customary strength. It is, therefore, very important, especially in warm weather, that all brick be wetted with water before they are laid in the wall.

As explained in *Cements*, lime or cement mortar does not set well in freezing weather. In New York City, there is a law against laying brick during freezing temperatures, but the law is not enforced owing to the scarcity of inspectors; consequently, in laying brick, it seems to make very little difference to the contractor or architect whether it is summer or winter—the work goes on just the same. On account of this disregard for the laws, many buildings erected during freezing weather either collapse or become weakened as soon as the weather gets warm. On the first warm spring day in 1905, in New York City, six large buildings of the "flat-house" type under construction fell in for no other reason than that just stated. These buildings would probably never have collapsed had proper precautions been taken.

BOND IN BRICKWORK

33. Lime mortar is not so strong as brick, at least for some time after it has set. It can easily be seen that if each brick in a wall were placed directly on another brick, any great weight imposed might cause the vertical mortar joints to split open. There is something more to be considered in laying brick than to place each one on a bed of mortar. A brick wall, if built correctly, must be tied together so that as much as possible of the strength of the brick will be utilized.

In bricklaying, all corners and joints should be carefully plumbed, the courses of brickwork kept perfectly horizontal—which necessitates uniform mortar joints—and the wall surfaces, both exterior and interior, must be kept in perfect alinement. All these conditions may have been complied with, and yet the work may be imperfect; the merit of the brickwork must be judged by the thoroughness of the *bond* observed in every portion of the wall, both lengthwise and crosswise. This bond must be maintained by having every course perfectly horizontal, both longitudinally and transversely, as well as perfectly plumb. Aside from the quality and character of the material, the *bonding* of a wall contributes most to its strength.

34. Terms Used in Bonding.—By **bonding** brickwork is meant the process of laying brick across one another so that one brick will rest on parts of two or three brick below it. This amounts to the same thing as breaking the joints. When built in this manner, it is difficult for a wall to fall without breaking the brick.

When the brick are placed lengthwise on the face of the wall, as at *a*, Fig. 6, they are termed **stretchers**; when placed crosswise and their ends only are exposed to view in

Fig. 6

the face of the wall, as at *b*, they are called **headers**. A **course** means the thickness of a brick and a mortar joint.

35. Keeping the Perpends.—To obtain the best results in bonding throughout the mass of the wall, strict attention must be given to the location of every joint in the brickwork. On the faces of the wall, the vertical joints in each course throughout the height should be kept perpendicular, or directly over those in the second course below. This is called **keeping the perpends**. Unless the closest attention is paid, the lap is ultimately lost through irregularity of the brick and mortar joints, and extra bats, or closers, become necessary. The joints across the top of the wall should also be kept in line, so that if the perpends are observed on one face of the wall, the other face will also

work up correctly. Even when the wall is exposed on only one face, the importance of having the joints on top of the wall kept in line is just as essential; otherwise, its effective longitudinal bond will soon be lost, since at best the heading bond furnishes a lap of only 2 inches.

36. Necessity of Preserving Bonding.—The importance of having the bond in brickwork preserved in the whole wall can be understood by referring to Fig. 6, which represents a section of a wall consisting of alternate courses of stretchers and headers. By the method of placing the brick as shown, no longitudinal bond exists, and the wall is simply a series of contiguous piers that join one another at the vertical lines *c d*, and have no bond or union between them other than that obtained by the adhesion of the mortar. This method manifestly lacks strength and stability. In order, therefore, to overcome this constructive difficulty and to secure a continuous bond in the length of the wall, recourse is had to a different arrangement of the bricks and also to the use of blocks that vary in size from the ordinary brick.

37. Closers and Bats.—The blocks of different sizes used for bonding are called **closers**, the term meaning that they perfectly finish, or close, the length of the courses that have been adjusted to obtain the bond. The vertical joint, which is shown at *c d*, Fig. 6, is avoided, and no two adjacent courses have joints that are immediately over each other. The closers are made by cutting the brick into such blocks as the situation requires, the operation being performed by striking a brick a sharp blow with the edge of a steel trowel. The cut brick are called **bats**, and are designated according to the proportion that each bat bears to the whole brick. Pressed and enameled brick are often cut with a cold chisel to get a more even fracture.

The different bats or closers used in brickwork are shown in Fig. 7, (*a*) representing a whole brick of the usual size. When a brick is cut longitudinally, as at (*b*), on line *a b*, each half is called a **queen closer**; but as it is difficult to cut the full length in this manner, the usual mode is to first

cut the brick on the line *c d e*, and then cut each half on the line *a b*. When the brick is cut as at (*c*), it is called a **king closer,** and is a form well adapted for closers at door and window jambs. When one-fourth of the whole length of the brick is cut off, as at (*d*), the remainder is called a **three-quarter bat;** and, in like manner, the portion remaining at (*e*) is called a **half bat;** and at (*f*), a **quarter bat.**

In connection with the use of closers, whereby the lap is properly secured, there are several methods of placing the brick in the wall, each method having its own name to indicate the kind of bond used. A wall being considered as having the properties of a column, its bearing capacity will

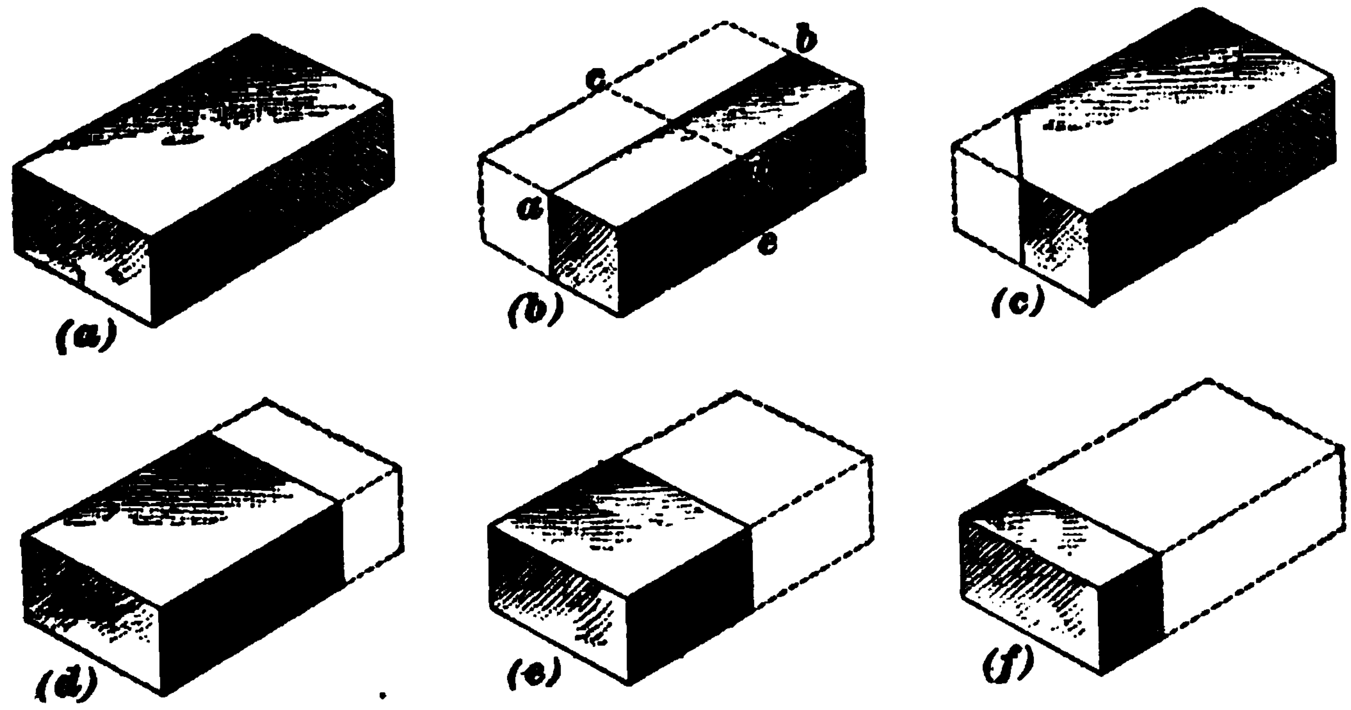


FIG. 7

necessarily depend on the strength of its least dimension, which is its thickness, so that the bond that secures a thorough union of the constituent parts in this direction will always be the most desirable.

38. Heading Bond.—When all the courses present the end of the brick in the face of the wall, the wall is then composed entirely of *headers*, and is known as the **heading bond.** This method, however, is only adapted for use in sharp-curved walls, as it possesses little longitudinal bond.

39. Stretching bond is the one employed when all the courses consist of *stretchers*. The wall formed by this method should only be used for partitions that are but

4 inches in thickness; where the wall is thicker than this, the method should not be followed, as there would be no transverse bond.

40. English Bond.—Though not much used in the United States, the **English bond** is probably the best and strongest method of bonding brickwork. In this bond, header and stretcher courses are laid alternately, as shown in Fig. 8. Joints are broken in the longitudinal bond courses by the use of quarter-bat closers, marked *c*. This is without doubt the best and simplest method to follow in all work where strength is required, as by its use a complete and thorough transverse bond is formed. It will be observed

FIG. 8

that the heart of the wall consists entirely of heading bond, and that the joints of the heading course, as at *a*, are well bonded by the headers of the stretching course, as at *b*.

Joints can be broken in English bond courses by the use of the three-quarter bats, and many authorities prefer them to quarter-bat closers, as by using three-quarter bats only one mortar joint instead of two shows in the face of the wall.

An objection frequently urged against the appearance of the English bond is the recurrence of so many headers in the face of the wall, which give the work the appearance of being constructed of so many tile-like blocks. The use of diminutive blocks of either brick or stone in heavy walls always tends to reduce the apparent strength of the structure, and it

loses much of the effect of permanence, which is a very effective factor in good design.

41. Flemish Bond.—The **Flemish bond** is one where only two-thirds of the number of headers that occur in English bond are exposed, and each course is composed of a header and a stretcher alternately. The method of laying the brick in Flemish bond is shown in Fig. 9. The lap in this case is obtained by the use of three-quarter bats, both at the external and the internal angles of the wall, as shown at *a* on the external and at *b* on the internal angles. In Flemish bond the closers occur in the heart of the wall, just as was shown in English bond; these are quarter, half, and three-quarter bats, as shown at *c*.

It will be seen by referring to the illustration that owing to the headers and stretchers being placed on the inner side of the wall immediately opposite those on the outer face, both faces will appear exactly alike when thus arranged. The wall is then said to be built in **double Flemish bond.**

By carefully examining the illustration, it will be found that only one-half of the body of the 4-inch thickness is bonded to the adjacent thickness; in other words, the upper bed of each face stretcher is bound to the inner thickness by only the width of one header. In this respect, the strength of the wall is sacrificed for the sake of appearance. A continuous vertical strip 2 inches wide occurs on each side of the face headers, and has no bond other than that of the

adhesion of the mortar. To obviate this defect, the outer face is sometimes built in Flemish bond and the inner face in English bond.

Flemish bond cannot be used for faced brick unless the common brick used on the inside of the wall are a trifle smaller, so as to lay up in even courses.

42. Garden, or Running, Bond.—The bond most extensively used in the United States, known as the **garden, or running, bond,** is shown in Fig. 10. This bond, which enables the bricklayer to build a larger amount of wall in a given time than can be accomplished by the use of either the English or the Flemish bond, is sometimes called **American bond.** It consists in laying from four to seven courses as stretchers and bonding with a row of headers at regular intervals. The longitudinal lap is secured by closers *c*; the heading course in the heart of the wall is shown at *a*, being placed immediately over the heading course *b* exposed on the face.

The principal defect of the running bond is that the wall is practically composed of a series of 4-inch layers from 12½ to 17½ inches in height, which have no transverse bond other than the mortar. It fulfils the requirements, however, if every joint throughout the body of the wall is well filled with good mortar and the vertical joints are well rammed with the edge of the trowel.

The New York building laws require that every sixth course shall be a header course; that is, that five courses of stretchers must come between two courses of headers. For factory and warehouse purposes, where the walls have to sustain heavy weights, it is better to have every fourth course a header course, thus giving three courses of stretchers between the header courses.

43. Bonding Face Brick.—When face or pressed brick are used for the exterior facing of a wall, it detracts from the uniform appearance of the brickwork if the bonding headers appear on the exterior face of the wall. There are several ways of avoiding this difficulty; either by cutting the face brick and the rough brick or by using steel-wire ties to bond the brick together. If no tie or bond is used, the whole 4 inches of brickwork on the face of the wall will have no other connections with the rest of the brick than that given by the adhesion of the mortar, and might be pushed away bodily from the rough brick.

44. In Fig. 11 is shown a 12-inch wall with the face brick bonded to the common brick by what is known as **diagonal,**

FIG. 11

or herring-bone, bond. At *a* is shown the front brick cut at the angles; at *b*, the bonding brick laid diagonally; at *c*, *c*, the different shaped bats laid to form the closers of the bond brick; and at *d*, the inside course of stretchers. It is customary to lay an inside course of headers immediately over the course shown in the figure.

The New York building laws require that "where walls are faced with brick in running bond, every sixth course shall be bonded into the backing by cutting the corners of the face brick and putting in diagonal headers behind, or by

FIG. 12

splitting the face brick in half and backing the same with a continuous row of headers." This last method is shown in Fig. 12. The face brick cut lengthwise are shown at *a*. At *b* are the three-quarter bats bonding in back of the face brick. The whole brick *c* bonds on the inside of the wall, the closer *d* closing up the angle, and *e* is the whole face brick on the corner of the wall.

FIG. 13

45. Metal Ties for Brickwork.—Fig. 13 illustrates the method of bonding in face brick with steel or galvanized-iron wire. These wire bonders *b* are twisted at the ends, and hold together the inside and outside courses *a* and *c*, as

shown. They are laid in every sixth course of brick. The principal objection to the use of steel or iron bonders is the danger of rust, although by the time their efficiency has been

Fig. 14

destroyed by the action of rust, the mortar used should have hardened sufficiently to keep the face brick in place.

A still better method of tying front brick to the common brick in the rear of the wall is by the use of perforated steel ties from $\frac{1}{16}$ to $\frac{1}{8}$ inch thick, and having about half the metal punched out. The brick may be brought down to a very close joint, and the clinching spaces make a very firm and satisfactory binder. Fig. 14 shows the application of these bonding strips. Here, *a* is the pressed-brick facing, *b* the common brick in the rear of the wall, and *c* the perforated steel ties bonding the pressed brick back to the common brick.

Fig. 15

The same tie can be used for tying new work to old where walls require lining up to increase their strength. The

tie is bent near the middle, as shown at *a* in Fig. 15, and is nailed to the old wall with pointed wrought-iron nails, shown at *b*. These nails have large flat heads made especially for this work, and are of sufficient size to make a firm connection for the new courses *c*. This method of tying avoids cutting in the old wall *d* to get in cross-headers, which, at best, must hold very imperfectly after the inevitable shrinkage that occurs in all new brickwork.

46. Bonding Hollow Walls.—In the ideal hollow wall, the air space is uninterrupted, having no braces connecting

FIG. 16

the inner and outer walls. Of course, in practice, it is necessary to have some bonding between the two walls, but the style of bonding should be carefully considered.

By permitting the passage of moisture through the wall where it is bonded, brick bonding neutralizes some of the

FIG. 17

benefit gained by making the walls hollow. To provide a continuous air space when a wall is penetrated by openings is practically impossible, though it may be closely approximated.

47. Fig. 16 shows one form of hollow wall with an 8-inch outer wall *a*, a 2-inch air space *b*, and a 4-inch inner wall *c*. This wall is bonded every sixth course in height, and every 8 inches in length, as shown at *d*. The header brick *e* that join the bond *d* are three-quarter bats, and the bond brick have 2 inches bearing on the front wall.

Fig. 17 shows a 10-inch wall that has a 4-inch wall *a*, then the 2-inch air space *b* and the inner 4-inch wall *c*. The bond brick are cut at an angle as shown at *d*, and where they miter in the front wall the front brick are also cut, as at *e*. The 2-inch space left in the rear wall *c* where the bond brick occur is filled with a closer *f*; this closer is a quarter bat.

48. Bonding With Metal Ties.—Probably the best method of bonding the two sides of a double wall is by the use of metal ties, as they will not carry any moisture across, especially when there is a dip or sudden bend in their length.

At *a*, Fig. 18, is shown a 4-inch wall; at *b*, the air space; at *c*, the inner 4-inch wall; and at *d*, the metal ties. These

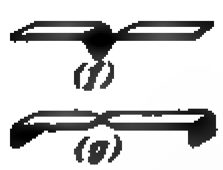


FIG. 18

ties are called *Morse patent ties*. At (*e*), (*f*), and (*g*) are shown other forms of ties. The form shown at (*g*) is probably the best, provided the walls are more than one brick thick so that the turned-up ends of the tie will not show.

When any of the metal ties *d*, (*e*), or (*f*) are used, they should be spaced every 24 inches in every fourth course. The

tie (g) being stronger need be used only in every eighth course. All metal ties should be dipped in hot asphalt to prevent them from rusting.

49. Bonding Hollow Walls With Brick Withes. Another method of bonding hollow walls is illustrated in Fig. 19. Both the inside and the outside walls are 4 inches thick. They depend for their strength not on a single tie of brick or wire spaced here and there, but are bonded by continuous brick partitions, or *withes*, as shown in the illustration. The wall is 20 inches thick and has a 12-inch space between the outer and inner walls. The outer brick wall

FIG. 19

is shown at a, the inner wall at b, and the withes, or connecting walls, at c. The bond is shown in two ways: at d, the bricks are cut, as shown, and at e the bond is made by wire bonders. The manner of placing the floorbeams on the inner wall is shown at f, and a $2'' \times \frac{1}{4}'' \times 20''$ anchor turned up at the end, to bond the floorbeam into the joint of the cross-wall, or withe, is shown at g.

A wall like the one just described must be built with extreme care, as its entire strength depends on the skill with which the two portions are bonded.

50. Bonding Walls at Angles.—In building brick walls, it is necessary that the angles in the walls be

properly bonded. When the two walls forming the angle are carried up at the same time, the bonding at the corners is easily effected; if, however, one wall is built first, due to a delay in getting materials required for the other wall, such as cast-iron lintels, etc., particular care must be taken that the two parts will bond together properly.

In such cases, the wall generally left toothed, a Fig. 20.

In order to unite the more firmly together, anch $\frac{3}{8}'' \times 2''$ wrought iron, w turned up 2 inches and the around a $\frac{3}{4}$-inch bar, sho into the side wall about in height, as shown at These anchors should be l to extend at least 12 in depth of one and one-ha the long way, as shown a side wall, and the center c bar should be about 8 inch back of the front wall.

51. In regard to the angles, the New York building laws are as follows:

In no case shall any wall or walls of any building be carried up more than two stories in advance of any other wall, except by permission of the Commissioner of Buildings having jurisdiction, but this prohibition shall not include the enclosure walls for skeleton buildings. The front, rear, side, and party walls shall be properly bonded together, or anchored to each other every six (6) feet in their height by wrought-iron tie-anchors, not less than one and one-half ($1\frac{1}{2}$) inches by three-eighths ($\frac{3}{8}$) of an inch in size, and not less than twenty-four

FIG. 20

(24) inches in length. The side anchors shall be built into the side or party walls not less than sixteen (16) inches, and into the front and rear walls, so as to secure the front and rear walls to the side, or party, walls when not built and bonded together.

JOINING NEW WALLS TO OLD WALLS

52. In joining a new wall to an old, when the walls come at right angles, the new work should not be toothed, or bonded, into the old work unless the new work is laid up in cement mortar. All masonwork built with lime mortar will settle somewhat, owing to a slight compression of the mortar joints, and this settlement is liable to cause a crack where old and new work is bonded together. In place of toothing,

Fig. 21

Fig. 22

or bonding, a groove should be cut perpendicularly in the old wall, usually the width of a brick, so as to make a joint; this is called a *slip joint.*

The method of bonding just described is shown in Fig. 21. At *a* is shown the groove or chase cut, where the new wall is to enter in the old wall; *c* is the new wall, and *d* the old wall.

In cheap construction, where new work is bonded into old, the method most commonly used is to nail a piece of 2″ × 4″ timber against the wall, as shown in Fig. 22, where *a* shows the 2″ × 4″ timber spiked to the old wall and entering the center of the new wall. At *b* is shown the old and at *c* the new wall.

HANGERS AND ARCHES FOR FLOORBEAMS IN BRICK WALLS

53. The use of joist and girder hangers, etc. simplifies greatly the work of framing, both for house and mill construction. With these hangers and anchors, a good and firm bearing may be had in brick walls. The chief requisite of a good hanger is that it shall hold firmly to the wall and at the same time hold firmly to the joist. Fig. 23 illustrates six styles of hangers used to support joists and beams against brick walls.

(a) (b) (c)

(d) (e) (f)

Fig. 23

It will be noted that with none of these six styles does the joist enter the wall. The top part of the hanger is built into the wall and the beam rests in the socket.

In the hangers shown at (*a*) and (*b*), the joist is held in place by one or two spikes or lagscrews driven in through the hole *a* of the hanger and into the wood. In hangers (*c*), (*d*), (*e*), and (*f*), there is a ridge, or lug, *b* cast on the hanger. A notch is cut across the bottom of the joist and the ridge of metal fits into this notch. The hangers at (*a*) and (*b*) are made of sheet steel stamped and bent into shape, while those

shown at (*c*), (*d*), (*e*), and (*f*) are made of cast steel. The one shown at (*f*) does not hold to the wall as firmly as some of the other designs, and is generally used above a corbel, as shown in the illustration. The hangers at (*a*) and (*b*) are known as the *Van Dorn hangers*, while those at (*c*), (*d*), and (*e*) are called *duplex hangers*. The one at (*f*) is a *Goetz hanger*.

54. In Fig. 24 are shown two templets on which the ends of wooden beams in walls may be placed. In (*a*), the teat *a* fits into a hole bored in the bottom of the beam with a brace and bit; while at (*b*) a groove is cut across the entire bottom of the beam into which the lug *b* fits. The flange *c* is

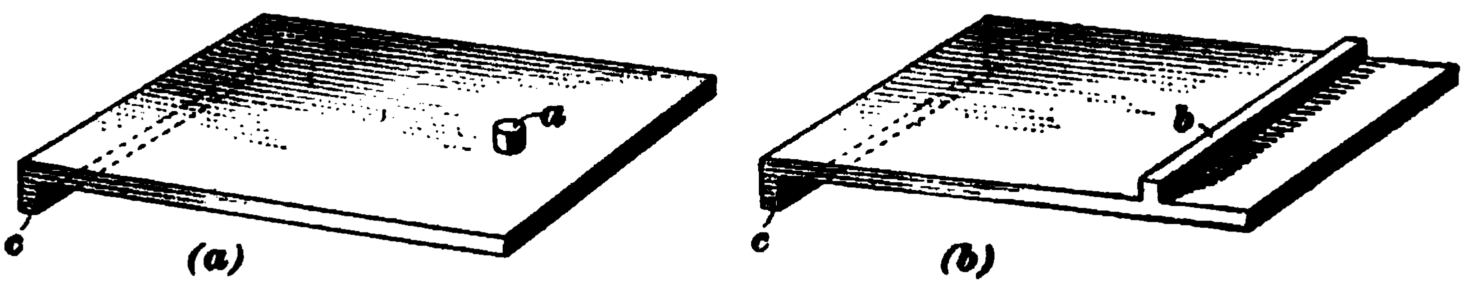


FIG. 24

sometimes made to turn up, but a better grip on the masonry is had when it turns down, as shown in the illustration.

55. In Fig. 25 are shown the four forms of iron anchors that are commonly used for fastening beams in brick walls. The one shown at (*a*) is made of $\frac{1}{4}'' \times 1\frac{3}{4}''$ iron, about 2 feet long; the end built in the wall is made of a $9'' \times \frac{5}{8}''$ rod with the end of the anchor drawn around it.

The anchor (*b*) is made of $2'' \times \frac{3}{16}''$ iron, 2 feet long; the end that goes in the wall is cut as shown, and about 4 inches is turned up at right angles to the anchor; the other end is twisted so that it can be nailed to the side of the joists.

An anchor that will run entirely through a wall is stronger than one that is simply embedded in a wall. On the other hand, the end of an anchor on the outside of a building makes an unsightly appearance. In warehouses and in back walls of buildings, however, when neat appearance is a secondary consideration, an anchor like that shown at (*c*) is used. It is made of $1\frac{3}{4}'' \times \frac{1}{4}''$ iron, 2 feet 6 inches long, and has a plate of $2'' \times 4'' \times \frac{1}{4}''$ iron forged on the

outer end. This style of anchor may also be used in the middle of a wall in the same manner as the ones shown at (*a*) and (*b*).

At (*d*) is shown probably the strongest form of anchor.

(b)

Fig. 25

This style of anchor is made by flattening out a $\frac{3}{4}$-inch bolt so as to make a $2'' \times \frac{1}{4}''$ portion to spike to the joist, and it is provided with a 5-inch cast-iron washer. A nut is placed

Fig. 26

on the outer side of the washer so that the anchor may be tightened up if necessary after the walls are built.

Anchors should always be spiked to the side of the joist or girder near the bottom, as shown at (*a*). If the anchor is

placed near the top of the joist, the destructive effect on the wall, should the joist fall, will be materially increased.

Fig. 26 shows the method of anchoring joists to walls where the joists and the walls run parallel. The anchor, let into the floor joists as shown at *a*, is provided with a washer *b*, and should be long enough to run over two or three joists, in order to give proper stiffness. The floor joists are shown at *c*, and the top of the 12-inch brick wall at *d*.

56. Fig. 27 illustrates common forms of ties for anchoring I beams, channels, etc. to brick walls. Ordinary wall

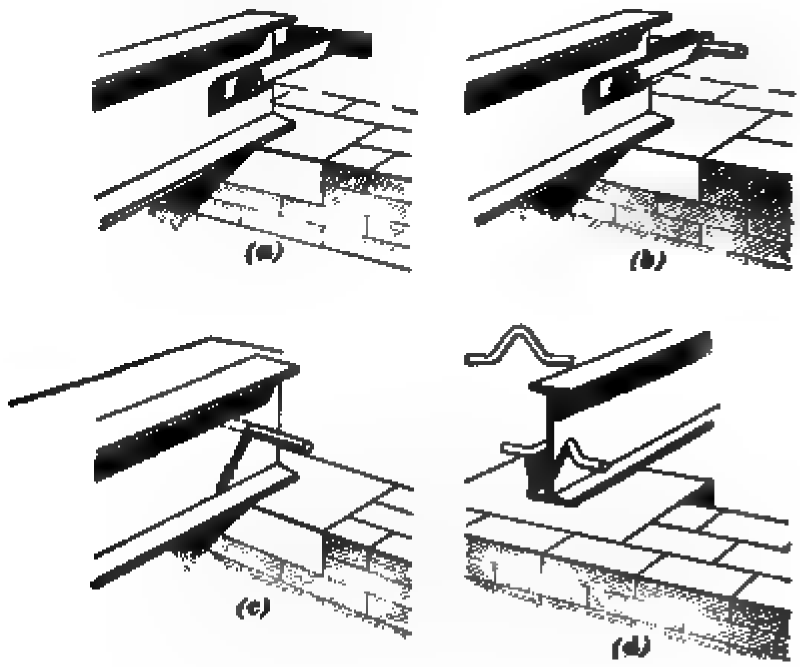


FIG. 27

anchors are shown at (*a*), (*b*), (*c*), and (*d*), while (*e*) represents a tie-rod anchor running through the wall, to be used when the beam is run parallel to the wall.

CORBELING FOR FLOOR JOISTS

57. Floor joists are sometimes supported by corbels built out from the walls. This method is required under certain conditions in the building laws of Chicago, as it allows the wall to be run up solid. The corbel usually projects 4 inches, and is composed of three courses of brick. At *a*, Fig. 28, is shown the brick corbel; *b*, *b* shows the wooden floor joists; *c* is a strip of plank placed between the floor joists, to provide nailing space for the rough flooring;

Fig. 28

d is the rough flooring, and *e* the tongued-and-grooved flooring; *f* is the 1″ × 2″ furring on the wall, and *g*, the lath and plaster over the furring strips. The dotted line *h* shows the outline of a plaster cornice that is usually put on under continuous corbels so as to give the room below a finished appearance.

Corbeling out for the floor joists has several advantages, one being that, in case of fire, the corbels act as a fire-stop, largely preventing the spread of the flames from story to story; and, in case the floor joists fall, they are inserted

such a short distance in the wall that they will not have so much tendency to pull the wall over as if anchored. The wall is also much stronger when corbeled out, for whenever timbers extend into a wall, they lessen the section, or bearing area, by just the amount of space taken up by the ends of the floor joists, and in partition and party walls this is considerable.

INSPECTION OF WORK

58. When superintending the erection of brickwork, the architect should see that sufficient mortar is used to fill all the joints. The quality of mortar should be frequently looked after, and nothing but the specified ingredients should be allowed to enter into its composition. The bonding of the walls should be well watched, in order to see that the number of bond courses, specified or required, are put in. Piers should be especially looked after, as their efficiency depends largely on the thoroughness of the bonding.

It should also be seen that the figured dimensions are properly checked and followed; courses kept level and walls plumb; floor anchors securely built in; and that all recesses for soil, vent, steam, and gas pipes are left in the proper places; also, that all unfinished brickwork and stonework is properly protected from the weather.

COMMON BRICKWORK
(PART 2)

WALLS, PIERS, LINTELS, AND CHIMNEYS

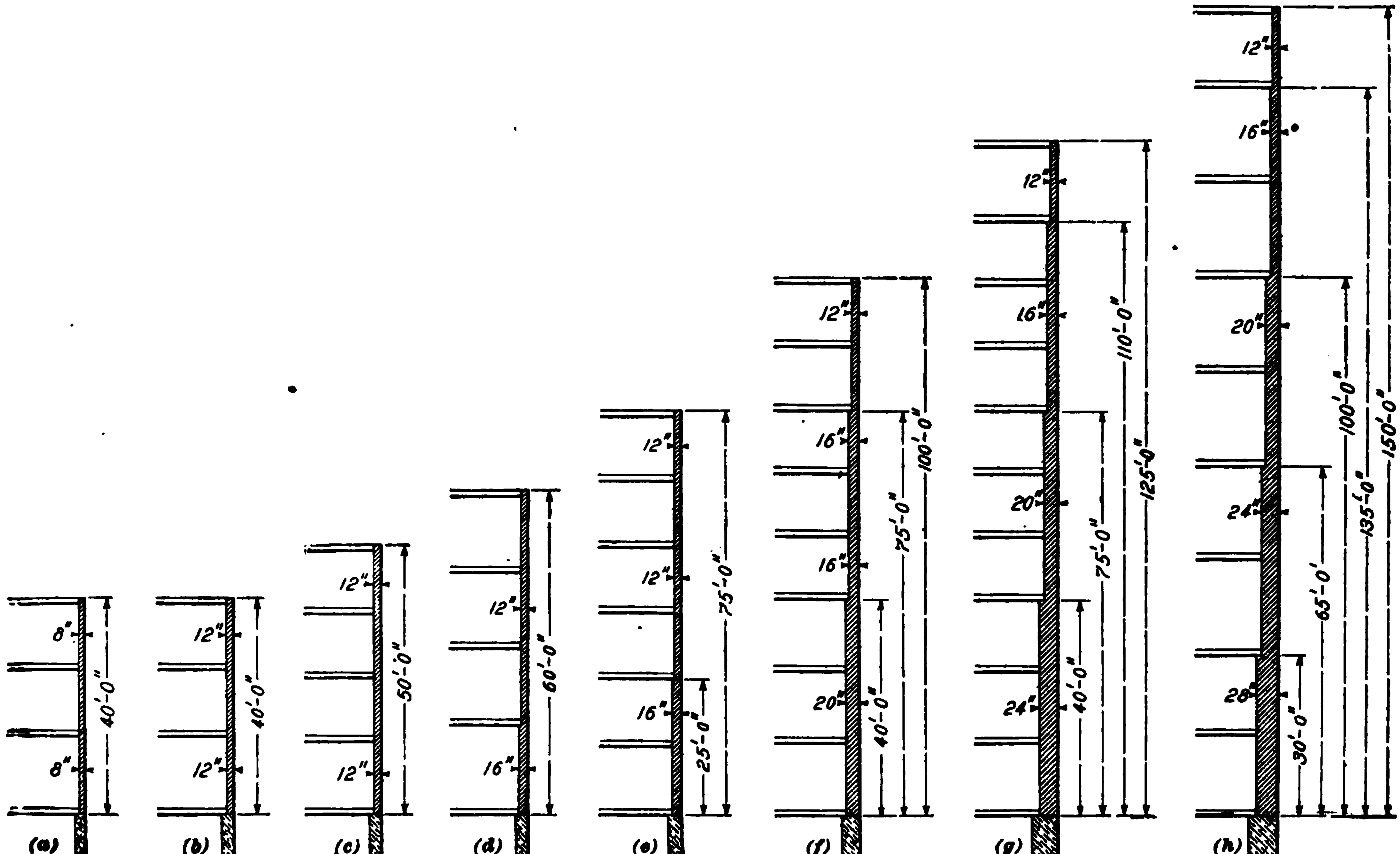
THICKNESS OF BRICK WALLS

1. In order that the design and construction of walls for buildings of various dimensions used for dwellings, warehouses, and other purposes may be carried out intelligently, a knowledge of the thickness of walls required is very important. With this object in mind, an extract is given from the building laws of New York City that relate to the thickness of brick walls in proportion to their height. The laws of other cities do not differ very materially from the New York laws, and these may therefore be safely taken as a standard.

WALLS FOR DWELLING HOUSES

2. The expression "walls for dwelling houses" shall be taken to mean and include in this class walls for the following buildings: Dwellings, asylums, apartment houses, convents, club houses, dormitories, hospitals, hotels, lodging houses, tenements, parish buildings, schools, laboratories, studios.

1. The walls above the basement of dwelling houses not over three stories and basement in height, nor more than 40 feet in height, and not over 20 feet in width, and not over 55 feet in depth, shall have side and party walls not less than 8 inches thick [see Fig. 1 (*a*)], and front and rear walls not less than 12 inches thick.



8"
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75'-0"
110'-0"
125'-0"
12"
16"
20"
24"
28"
30'-0"
65'-0'
100'-0"
135'-0"
150'-0"
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)

FIG. 1

2. All walls of dwellings exceeding 20 feet in width and not exceeding 40 feet in height, shall be not less than 12 inches thick [see Fig. 1 (*b*)].

3. All walls of dwellings 26 feet or less in width between bearing walls which are hereafter erected or which may be altered to be used for dwellings and being over 40 feet in height and not over 50 feet in height, shall be not less than 12 inches thick above the foundation walls [see Fig. 1 (*c*)].

No wall shall be built having a 12-inch thick portion measuring vertically more than 50 feet.

4. If over 50 feet in height and not over 60 feet in height, the walls shall be not less than 16 inches thick in the story next above the foundation walls and from thence not less than 12 inches to the top [see Fig. 1 (*d*)].

5. If over 60 feet in height, and not over 75 feet in height, the walls shall be not less than 16 inches thick above the foundation walls to the height of 25 feet, or to the nearest tier of beams to that height, and from thence not less than 12 inches thick to the top [see Fig. 1 (*e*)].

6. If over 75 feet in height, and not over 100 feet in height, the walls shall be not less than 20 inches thick above the foundation walls to the height of 40 feet or to the nearest tier of beams to that height, thence not less than 16 inches thick to the height of 75 feet, or to the nearest tier of beams to that height, and thence not less than 12 inches thick to the top [see Fig. 1 (*f*)].

7. If over 100 feet in height and not over 125 feet in height, the walls shall be not less than 24 inches thick above the foundation walls to the height of 40 feet, or to the nearest tier of beams to that height; thence not less than 20 inches thick to the height of 75 feet, or to the nearest tier of beams to that height; thence not less than 16 inches thick to the height of 110 feet, or to the nearest tier of beams to that height; and thence not less than 12 inches thick to the top [see Fig. 1 (*g*)].

8. If over 125 feet in height and not over 150 feet in height, the walls shall be not less than 28 inches thick above the foundation walls to the height of 30 feet, or to the nearest tier of beams to that height; thence not less than 24 inches thick to the height of 65 feet, or to the nearest tier of beams to that height; thence not less than 20 inches thick to the height of 100 feet, or to the nearest tier of beams to that height; thence not less than 16 inches thick to the height of 135 feet, or to the nearest tier of beams to that height; and thence not less than 12 inches thick to the top [see Fig. 1 (*h*)].

9. If over 150 feet in height, each additional 30 feet in height or part thereof, next above the foundation walls, shall be increased 4 inches in thickness, the upper 150 feet of wall remaining the same as specified for a wall of that height.

WALLS FOR WAREHOUSES

3. The expression "walls for warehouses" shall be taken to mean and include in this class walls for the following buildings: Warehouses, stores, factories, mills, printing houses, pumping stations, refrigerating houses, slaughter houses, wheelwright shops, cooperage shops, breweries, light and power houses, sugar refineries, office buildings, stables, markets, railroad buildings, jails, police stations, court houses, observatories, foundries, machine shops, public assembly buildings, armories, churches, theaters, libraries, museums.

1. The walls for all warehouses, 25 feet or less in width between walls or bearings, shall be not less than 12 inches thick to the height of 40 feet above the foundation walls [see Fig. 2 (*a*)].

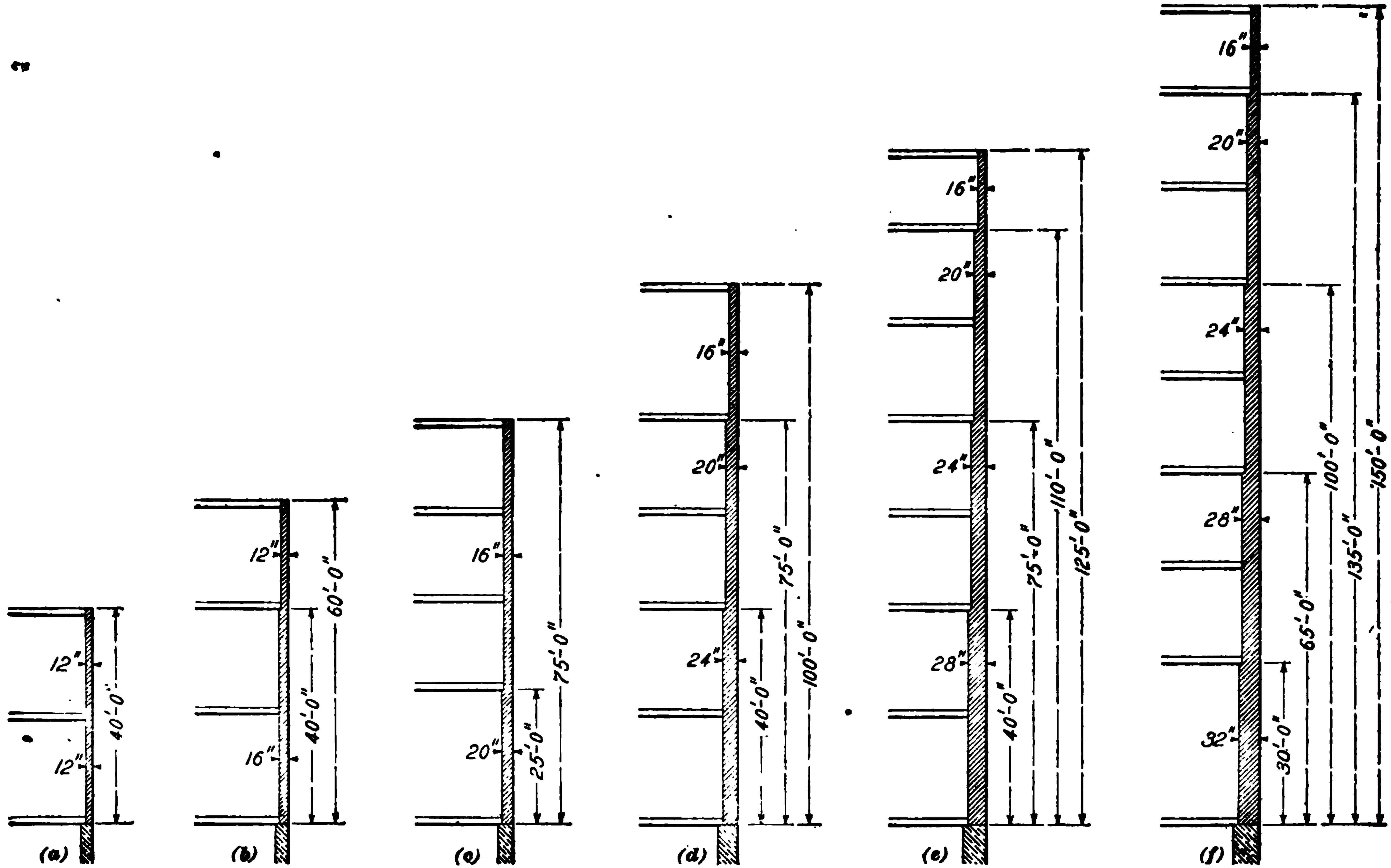
2. If over 40 feet in height, and not over 60 feet in height, the walls shall be not less than 16 inches thick above the foundation walls to the height of 40 feet, or to the nearest tier of beams to that height, and thence not less than 12 inches thick to the top [see Fig. 2 (*b*)].

3. If over 60 feet in height, and not over 75 feet in height, the walls shall be not less than 20 inches thick above the foundation walls to the height of 25 feet, or to the nearest tier of beams to that height, and thence not less than 16 inches thick to the top [see Fig. 2 (*c*)].

4. If over 75 feet in height, and not over 100 feet in height, the walls shall be not less than 24 inches thick above the foundation walls to the height of 40 feet, or to the nearest tier of beams to that height; thence not less than 20 inches thick to the height of 75 feet, or to the nearest tier of beams to that height; and thence not less than 16 inches thick to the top [see Fig. 2 (*d*)].

5. If over 100 feet in height, and not over 125 feet in height, the walls shall be not less than 28 inches thick above the foundation walls to the height of 40 feet, or to the nearest tier of beams to that height; thence not less than 24 inches thick to the height of 75 feet, or to the nearest tier of beams to that height; thence not less than 20 inches thick to the height of 110 feet, or to the nearest tier of beams to that height; and thence not less than 16 inches thick to the top [see Fig. 2 (*e*)].

6. If over 125 feet in height, and not over 150 feet, the walls shall be not less than 32 inches thick above the foundation walls to the height of 30 feet, or to the nearest tier of beams to that height; thence not less than 28 inches thick to the height of 65 feet, or to the nearest tier of beams to that height; thence not less than 24 inches thick to the height of 100 feet, or to the nearest tier of beams to that height; thence not less than 20 inches thick to the height of 135 feet or to the nearest tier of beams to that height; and thence not less than 16 inches to the top [see Fig. 2 (*f*)].



12"
12"
40'-0"
(a)
12"
16"
40'-0"
60'-0"
(b)
16"
20"
25'-0"
75'-0"
(c)
16"
20"
24"
40'-0"
75'-0"
100'-0"
(d)
16"
20"
24"
28"
40'-0"
75'-0"
110'-0"
125'-0"
(e)
16"
20"
24"
28"
32"
30'-0"
65'-0"
100'-0"
135'-0"
150'-0"
(f)

Fig. 2

7. If over 150 feet in height, each additional 25 feet in height, or part thereof next above the foundation walls shall be increased 4 inches in thickness, the upper 150 feet of wall remaining the same as specified for a wall of that height.

THICKNESS OF WALLS IN DIFFERENT CITIES

4. Although alike in the main, the building laws of the several cities differ from one another in many points, particularly in the methods of measuring the thickness of walls. For this reason, Tables I and II have been compiled, the former giving the thickness of warehouse walls and the latter the thickness of walls for residences. Some cities, like New York and Boston, for instance, give the thickness of walls to various heights in feet; others, notably New Orleans and Denver, measure the heights in stories; while still others, like Washington and Cleveland, specify that a certain thickness of wall shall extend to a certain story, but state that this story must not be more than a given number of feet from the foundation. Therefore, in preparing the tables, several heights of stories were selected, so that all the laws could be made to apply to the same case. In every instance where the law required that the walls be thicker as the building is made wider, the minimum width was used; as in New York, 25-foot span, and in Philadelphia, 26-foot span. It will be noticed in Table I that dimensions for very high buildings are not given for some cities. This is because in many cases the height of buildings is limited in those localities. In Denver, a building cannot be over 125 feet in height, and in Washington, the government has limited the height to 130 feet.

The thickness of the walls in almost all the cities is given in inches. In Cleveland, however, the law gives the thickness of the wall in the number of brick, but the size of the brick and the thickness of the mortar joints are also specified, so that the figures can easily be reduced to inches. In Washington, the thickness of walls of residences is specified, and a note states that $4\frac{1}{2}$ inches must be added to this thickness for warehouse walls. In Table I however, 5 inches

instead of $4\frac{1}{2}$ inches is added, so as to eliminate all fractions. It will be noted that some laws call a wall evidently a brick and one-half thick 12 inches, while others call it 13 inches. This is due of course to different customs in different cities and the different size of brick used there. As the laws governing the thickness of foundations differ according to the locality, they cannot be given here, but may be found in the ordinances of the city or town in which the building is to be erected. In some of the cities, as, for instance, Philadelphia, Boston, and New Orleans, walls of the same thickness are used for both warehouses and residences. Tables I and II apply to brick walls only.

TABLE I

THICKNESS OF BRICK WALLS FOR WAREHOUSES

Name of City	Number of Stories and Height of Building	Story and Height of Each											
		First 19′	Second 13′ 4″	Third 13′ 4″	Fourth 13′ 4″	Fifth 13′ 4″	Sixth 13′ 4″	Seventh 13′ 4″	Eighth 13′ 4″	Ninth 13′ 4″	Tenth 13′ 4″	Eleventh 13′ 4″	Twelfth 13′ 4″
		Thickness of Brick Wall, in Inches											
Washington......		14	14										
St. Louis.........		18	13										
Denver..........		13	13										
Memphis.........		13	13										
Boston..........		16	12										
New York.......	Two stories	12	12										
Philadelphia	32 feet 4 inches	18	13										
Chicago..........		12	12										
Minneapolis......		12	12										
New Orleans.....		13	13										
Cleveland........		13	13										
San Francisco....		17	13										

α

Name of City	Number of Stories	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Ninth	Tenth	Eleventh	Twelfth
Washington		23	18	18									
St. Louis		18	18	13									
Denver		17	17	13									
Memphis		17	17	13									
Boston		20	16	16									
New York	Three stories	16	16	12									
Philadelphia	45 feet 8 inches	22	13	13									
Chicago		16	12	12									
Minneapolis		16	12	12									
New Orleans		13	13	13									
Cleveland		17	13	13									
San Francisco		17	17	13									
Washington		23	18	18	18								
St. Louis		22	18	18	13								
Denver		21	17	17	13								
Memphis		21	17	17	13								
Boston		20	16	16	16								
New York	Four stories	16	16	16	12								
Philadelphia	59 feet	22	18	13	13								
Chicago		20	16	16	12								
Minneapolis		16	16	12	12								
New Orleans		18	18	13	13								
Cleveland		17	17	13	13								
San Francisco		17	17	17	13								

TABLE I—(*Continued*)

Name of City	Number of Stories and Height of Building	Story and Height of Each											
		Thickness of Brick Wall, in Inches											
Washington......		27	23	23	23	18							
St Louis.........		22	22	18	18	13							
Denver.....		21	21	17	17	13							
Memphis.........		21	21	17	17	17							
Boston..........		20	20	20	20	16							
New York.......	Five stories	20	16	16	16	16							
Philadelphia	72 feet 4 inches	26	18	18	13	13							
Chicago.........		20	20	16	16	16							
Minneapolis......		20	16	16	12	12							
New Orleans.....		18	18	18	13	13							
Cleveland........		17	17	17	13	13							
San Francisco....		21	17	17	17	13							

Name of City	Number of Stories	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Ninth	Tenth	Eleventh	Twelfth
Washington......	Six stories 85 feet 8 inches	31	27	23	23	23	18						
St. Louis.........		26	22	22	18	18	13						
Denver..........		26	21	21	17	17	13						
Memphis.........		25	21	21	17	17	17						
Boston..........		24	20	20	20	20	16						
New York.......		24	24	24	20	20	16						
Philadelphia.....		26	22	18	18	13	13						
Chicago..........		20	20	20	16	16	16						
Minneapolis......		20	20	16	16	16	12						
New Orleans.....		22	18	18	18	13	13						
Cleveland........		22	17	17	17	13	13						
San Francisco....		21	21	17	17	17	13						
Washington......	Seven stories 99 feet	31	27	27	23	23	23	18					
St. Louis.........		26	26	22	22	18	18	13					
Denver..........		26	21	21	21	17	17	17					
Memphis.........		25	21	21	21	17	17	17					
Boston..........		24	20	20	20	20	20	16					
New York.......		24	24	24	20	20	16	16					
Philadelphia.....		30	22	22	18	18	13	13					
Chicago..........		20	20	20	20	16	16	16					
Minneapolis......		20	20	20	16	16	16	12					
New Orleans.....		22	22	18	18	18	13	13					
Cleveland........		22	22	17	17	17	13	13					

TABLE I—(*Continued*)

Name of City	Number of Stories and Height of Building	Story and Height of Each											
		First 19′	Second 13′ 4″	Third 13′ 4″	Fourth 13′ 4″	Fifth 13′ 4″	Sixth 13′ 4″	Seventh 13′ 4″	Eighth 13′ 4″	Ninth 13′ 4″	Tenth 13′ 4″	Eleventh 13′ 4″	Twelfth 13′ 4″
		Thickness of Brick Wall, in Inches											
Washington	Eight stories 112 feet 4 inches	39	35	35	31	27	27	23	23				
St. Louis		30	26	26	22	22	18	18	13				
Denver		30	26	21	21	21	17	17	17				
Memphis		29	25	21	21	21	17	17	17				
Boston		28	24	20	20	20	20	20	16				
New York		28	28	28	24	24	20	20	20				
Philadelphia		30	26	22	22	18	18	13	13				
Chicago		24	24	20	20	20	16	16	16				
Minneapolis		24	20	20	20	16	16	16	12				
New Orleans		22	22	22	18	18	18	13	13				
Cleveland		22	22	22	17	17	17	13	13				

Name of City	Number of Stories	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Ninth	Tenth	Eleventh	Twelfth
Washington......	Nine stories 125 feet 8 inches	39	35	35	31	27	27	23	23	23			
St. Louis.........		30	30	26	26	22	22	18	18	13			
Memphis.........		29	25	25	21	21	21	17	17	17			
Boston..........		28	28	24	20	20	20	20	20	16			
New York.......		32	32	28	28	24	24	24	20	20			
Philadelphia.....		34	26	26	22	22	18	18	13	13			
Chicago..........		24	24	24	20	20	20	16	16	16			
Minneapolis......		24	24	20	20	20	16	16	16	12			
Cleveland........		26	22	22	22	17	17	17	13	13			
St. Louis.........	Ten stories 139 feet	34	30	30	26	26	22	22	18	18	13		
Memphis.........		29	29	25	25	21	21	21	17	17	17		
Boston..........		32	28	28	24	20	20	20	20	20	16		
New York.......		32	32	28	28	24	24	24	20	20	20		
Philadelphia.....		34	30	26	26	22	22	18	18	13	13		
Chicago..........		28	28	24	24	24	20	20	20	16	16		
Minneapolis......		24	24	24	20	20	20	16	16	16	12		
Cleveland........		26	26	22	22	22	17	17	17	13	13		

TABLE I—(*Continued*)

Name of City	Number of Stories and Height of Building	Story and Height of Each											
		First 19′	Second 13′ 4″	Third 13′ 4″	Fourth 13′ 4″	Fifth 13′ 4″	Sixth 13′ 4″	Seventh 13′ 4″	Eighth 13′ 4″	Ninth 13′ 4″	Tenth 13′ 4″	Eleventh 13′ 4″	Twelfth 13′ 4″
		Thickness of Brick Wall, in Inches											
St. Louis.........	Eleven stories 152 feet 4 inches	34	34	30	30	26	26	22	22	18	18	13	
Memphis.........		29	29	25	25	25	21	21	17	17	17	17	
Boston..........		32	32	28	28	[illegible]	20	20	20	20	20	16	
New York.......		36	32	28	28	28	24	24	20	20	20	16	
Philadelphia		38	30	30	26	26	22	22	18	18	13	13	
Chicago..........		28	28	24	24	24	20	20	20	16	16	16	
Cleveland........		31	26	26	22	22	22	17	17	17	13	13	
St. Louis.........	Twelve stories 165 feet 8 inches	34	34	34	30	30	26	26	22	22	18	18	13
Memphis.........		29	29	29	25	25	25	21	21	21	17	17	17
Boston..........		36	32	32	28	28	24	20	20	20	20	20	16
New York.......		36	32	32	28	28	28	24	24	20	20	20	16
Philadelphia		38	34	30	30	26	26	22	22	18	18	13	13
Chicago..........		28	28	28	24	24	24	20	20	20	16	16	16
Cleveland........		31	31	26	26	22	22	22	17	17	17	13	13

TABLE II

THICKNESS OF BRICK WALLS FOR DWELLING HOUSES

Name of City	Number of Stories and Height of Building	First 12′	Second 11′	Third 10′ 6″	Fourth 10′	Fifth 10′	Sixth 10′	Seventh 10′	Eighth 10′
		Thickness of Brick Wall, in Inches							
New York .		12	12						
Denver		13	13						
Washington	Two stories	9	9						
Cleveland ..	23 feet	13	13						
Chicago....		12	8						
Memphis ..		13	13						
New York..		12	12	12					
Denver		17	13	13					
Washington	Three stories	9	9	9					
Cleveland ..	33 feet 6 inches	13	13	13					
Chicago		12	12	8					
Memphis ...		13	13	13					
New York..		12	12	12	12				
Denver		17	17	13	13				
Washington	Four stories	13	13	13	13				
Cleveland ..	43 feet 6 inches	18	13	13	13				
Chicago		16	16	12	12				
Memphis ..		13	13	13	13				
New York..		16	12	12	12	12			
Denver		21	21	17	17	13			
Washington	Five stories	18	13	13	13	13			
Cleveland ..	53 feet 6 inches	18	18	13	13	13			
Chicago		16	16	16	12	12			
Memphis...		17	13	13	13	13			
New York..		16	16	12	12	12	12		
Denver		26	21	21	17	17	13		
Washington	Six stories	22	18	18	13	13	13		
Cleveland ..	63 feet 6 inches	18	18	18	13	13	13		
Chicago		20	16	16	16	12	12		
Memphis...		17	17	13	13	13	13		
New York..		16	16	12	12	12	12		
Denver		26	21	21	21	17	17	17	
Washington	Seven stories	22	18	18	18	13	13	13	
Cleveland ..	73 feet 6 inches	18	18	18	18	13	13	13	
Chicago		24	20	20	16	16	12	12	
Memphis...		17	17	17	13	13	13	13	
New York..		20	20	20	16	16	16	16	12
Denver		30	26	21	21	21	17	17	17
Washington	Eight stories	26	22	18	18	18	13	13	13
Cleveland ..	83 feet 6 inches	22	18	18	18	18	13	13	13
Chicago		24	24	20	20	16	16	12	12
Memphis...		21	17	17	17	13	13	13	13

TYPES OF BRICK WALLS

5. Solid Walls.—The solid brick walls of a building are not waterproof. A driving rainstorm of several days' duration will sometimes penetrate even a 2-foot wall and by wetting the inside surfaces, spoil whatever interior coverings the wall may have.

A house built of solid walls is likely to be cold in winter, warm in summer, and damp at all times. In solid brickwork, there is always a lack of insulation against heat and moisture.

Air is about the best, and certainly the cheapest, form of insulation. To obtain air insulation, several methods are resorted to. The one most in use consists in furring the inner surface of outside brick walls with furring strips and then fastening the lath and plaster to these strips. The danger of fire spreading from floor to floor through the spaces between the furring strips, especially in hospitals, schoolhouses, and isolated private residences, has caused many excellent authorities to recommend the use of hollow brick walls in their stead.

6. Hollow Walls.—Hollow walls are intended to keep moisture from passing through, and, by providing an air space, keep the building much cooler in summer and warmer in winter. Difficulties that largely offset their advantages are met with in construction, however, so that hollow walls are not often used in this country. There is no doubt but that their use might be much extended with good results, more especially for isolated buildings. The objections to hollow walls are that more ground area is required and the cost of construction is increased.

7. Party Walls.—A **party wall** is a wall that separates two adjoining buildings and carries the floor and roof beams of both of them. A party wall is sometimes owned jointly by the two persons who own adjacent property—in this case the center line of the party wall marks one of the boundary lines of the lot—or the right to use the wall for floor and

roof beams may be purchased at the time of the erection of an adjoining building.

The floor loads on party walls are twice as great as the load on any outside wall; besides this, the necessity for thorough and complete fire-protection is greater in party walls than in outside walls, because those on the outside can easily be reached in case of fire, while party walls, being enclosed by other walls, are more difficult of access. As building regulations differ materially in regard to the thickness of party walls, the best guide for determining their thickness is to make them 4 inches thicker in each story than the outside wall.

8. Curtain Walls.—In modern skeleton construction, the floor loads in a building are carried on the steel frame, and the walls carry no load other than their own weight. There are a few high buildings in which the walls extend down to the foundations, but because it is desired to make these walls thin on account of the space they occupy and the high price of real estate in the business sections of cities, curtain walls are generally supported on the steel frame of the building, usually at every floor. In this way much thinner walls can be used, and valuable space can be saved.

9. Following is an extract in regard to curtain walls from the New York City building laws:

Walls of brick built in between iron or steel columns, and supported wholly or in part on iron or steel girders, shall be not less than 12 inches thick for 75 feet of the uppermost height thereof, or to the nearest tier of beams to that measurement, in any building so constructed, and every lower section of 60 feet, or to the nearest tier of beams to such vertical measurement, or part thereof, shall have a thickness of 4 inches more than is required for the section next above it down to the tier of beams nearest to the curb level.

10. Veneered Walls.—Frame houses are frequently incased in a 4-inch veneer of brick, which is usually placed directly against the wood, but preferably should be separated from it by a 2-inch air space. Veneered walls are cheaper than those built of solid brick. Houses constructed in this fashion are warmer in winter and cooler in summer, and are

also less likely to catch fire from outside sources than are ordinary frame buildings. It is not to be construed, however, that a veneered wall is better than a solid brick wall, for it really will last no longer than the wooden frame that it covers.

11. In building a house with veneered walls, the foundation must project far enough beyond the line of the studs to carry the brickwork that is put on later. This requires a projection of 1 inch for sheathing, 2 inches for air space, 4 inches for brick, and an extra allowance for any projection that might be required by the building laws of the city in which the house is built.

Care must be taken to construct the frame in the best manner, and the timber used in framing should be extra heavy, for the brick veneer carries absolutely no part of the building except its own weight, and in fact has to be tied to the wood framing for support. After the frame is up it should be sheathed diagonally and, although omitted from Figs. 3 and 4 for sake of clearness, the sheathing should always be covered with tar paper or other waterproof material on the outside before the bricks are laid, no matter how wide the air space may be. All the framing timber, particularly the sills and girths, should be as dry as possible, and the frame must be perfectly plumb and straight; if not, the brick veneer will not lay up properly.

(a) (b)

FIG. 3

Pressed, or face, brick are usually tied to the diagonal sheathing with metal ties. The wire tie known as the Morse tie, shown in Fig. 3 (*a*), is most generally used, though a tie made of No. 16 iron, 1¼ inches wide, with the end turned up, as shown in Fig. 3 (*b*), gives satisfactory results. The

ties should be placed on every other brick in every fifth course of brickwork.

Ventilation is usually provided for by means of a 2-inch drain tile at the bottom, as shown at *o*, Fig. 4. This drain serves also as an outlet for any moisture that may collect in the air space.

FIG. 4

12. Fig. 4 shows a section through part of the foundation of a veneered building and the principal features of its construction. At *a* is shown the stone foundation wall, projecting 6 inches beyond the diagonal sheathing *b*; the 6″ × 4″ sill is shown at *c*, the 3″ × 10″ floor joist at *d*, and the air space between the brickwork and the sheathing at *e*. The 4-inch brick-veneer wall is shown at *f*, and the wire tie at *g*; the stone window sill is shown at *h*, the 2″ × 4″ studding at *k*, the lathing at *l*, the flooring at *m*, and the window frame at *n*.

TERRA-COTTA FURRING

13. A common form of construction, especially in fireproof and waterproof walls, is one in which either terra-cotta blocks or hollow bricks are used.

In Fig. 5 is shown a wall that is furred with hollow blocks, which are usually $1\frac{1}{2}$ or 2 inches thick and 12 inches square. They are laid in gauged mortar, and are held in position by tenpenny nails, one nail being driven through every other block into a joint in the brickwork.

A wall furred with hollow brick is illustrated in Fig. 6. Special brick are made for headers, so that the holes in the brick will all run the same way. The hollow brick are made of porous terra cotta so that nails can be driven into them. They are therefore not entirely waterproof, but in thick walls where the conditions are favorable, they are sufficiently dense to exclude all moisture. According to the New York building laws, they may be counted as part of the thickness of a brick wall. Both the hollow bricks and the 12-inch square blocks are grooved on the face, as shown, to provide a clinch for the plaster.

OPENINGS IN WALLS

14. Openings in Solid Walls.—When a brick wall contains door and window openings, their location and relative position should be very carefully considered, not only with regard to convenience and symmetry, but also with regard to their effect on the strength of the wall. When walls are broken frequently by windows and other openings, cracks are more likely to occur than when the wall is plain and unbroken. This is owing to the unequal pressure on the mortar joints. If walls are well bonded and anchored, the danger of cracks may be reduced to a minimum.

In any bearing wall carrying the ends of floorbeams, the combined width of openings should not be more than one-third the total length of the wall, unless the thickness of the wall between the windows is increased by the use of piers, pilasters, or buttresses. When possible, the window

Fig. 5

159

Fig. 6

140

openings in the different stories should be placed directly over one another.

Unless absolutely necessary, the placing of windows under a pier or directly over a narrow mullion should always be

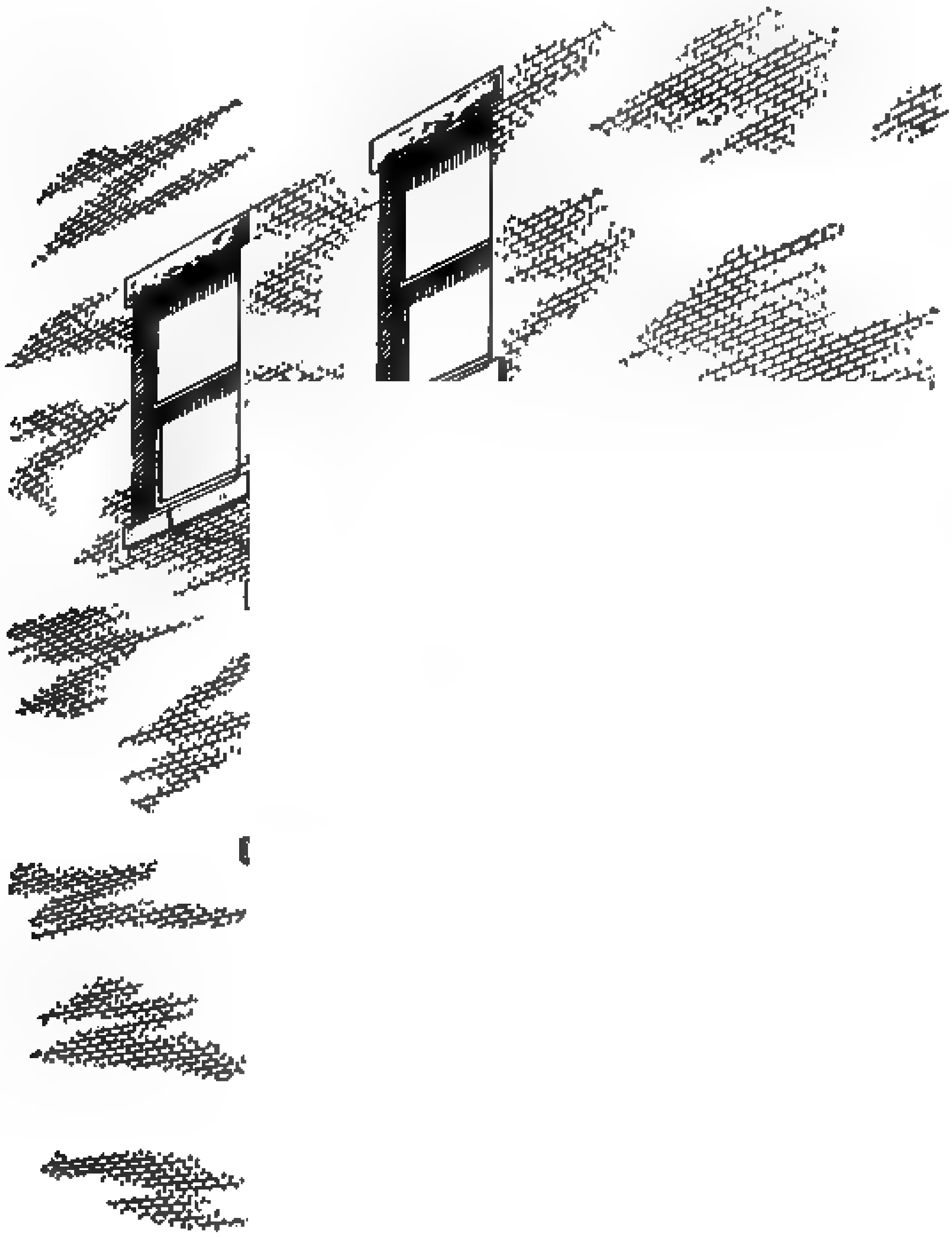


FIG. 7

avoided. The effect of such an arrangement is shown in Fig. 7. At *a* is shown a window opening under a pier; the combined effects of the load of brickwork and the settlement of the joints cause the sills of the upper windows and the

causing the load to bear equally on each brick used in the construction.

The bond stones should be either granite, bluestone, or one of the durable limestones. The blue Vermont marble is also used, but the softer sandstones and freestones should be avoided.

In Figs. 9 and 10 are shown the two types of bonded brick piers. The former illustrates a pier bonded with 4-inch bond stones *b*, and the latter, a brick pier with 1-inch iron bonding plates *a*. Each pier has a stepped-up brick foundation *c* and a concrete base *d*.

BRICK NOGGING

17. Stud partitions in brick buildings and the space between the outside studs in wooden houses are often filled with brickwork, to obstruct as much as possible the passage of fire, sound, and vermin. As there is no special weight placed on the brick, the cheapest quality may be used for this purpose, such as the pale, or salmon, brick from the outer portion of a brick kiln. The brick should be laid in mortar as in a 4-inch brick wall.

When the wall is lathed with wooden laths, there should be a small space left between the brick nogging and the laths, so that the plaster will have sufficient room for a clinch.

LINTELS AND RELIEVING ARCHES

18. Iron Lintels.—All windows and other openings in exterior walls, especially if they are in bearing walls, should have either relieving arches, cast-iron lintels, or iron or steel I beams behind the stone lintels, or face arches. When the width of the window opening is less than 6 feet, it is usual to put in relieving arches. Steel or iron I beams or cast-iron lintels, preferably the former, are used for greater widths. If the top of a window or door opening in a bearing wall comes within 12 inches of the bottom of the floor joists over the opening, relieving arches should not be used, especially in warehouses or where there are heavy loads on the floors.

The best lintels for use in unplastered brick partitions in warehouses are cast iron, as shown in Fig. 11, where (*a*) shows the elevation and (*b*) the section of the lintel. The line *a c* is the bottom of the lintel, and the dotted line *b* the

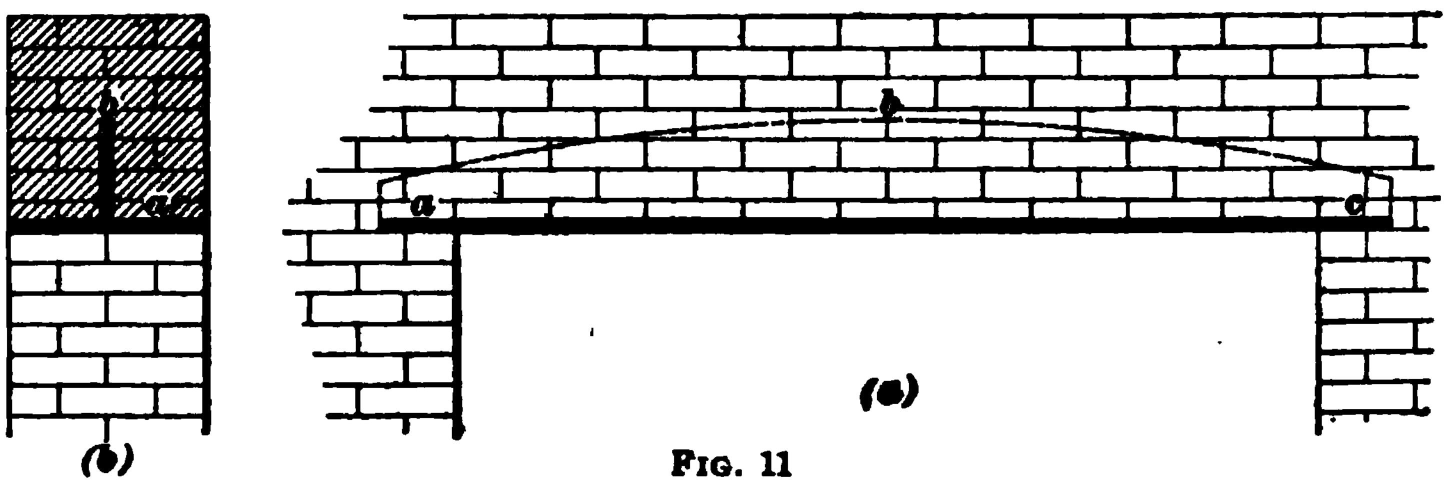


FIG. 11

top of the arched web. The advantage in using this form of lintel is that it gives a smooth surface to the soffit, or under side of the arch, and shows only a narrow strip of metal on the face of the wall.

19. Wooden Lintels.—As a rule, the lumber supplied for building construction is never completely seasoned and dried. Therefore, after a building is finished and heated, the wood will dry more thoroughly and will shrink. On this account, it is advisable not to paper the walls of a frame house until some months after the house has been heated, because the shrinkage of the timbers will crack the plaster, which in turn will ruin the wallpaper. After a house has become thoroughly dried out, and shrinkage and settling have ceased, any cracks that occur in the plaster may be repaired, and the wallpaper then put on with absolute safety.

On account of the danger resulting from shrinkage, wood should never be used in brick walls if possible to avoid it. Fig. 12 illustrates the disastrous results that usually follow where wood is used. Here, the wooden lintel *b* over a door in the wall *c* has shrunk and caused the crack *a*, *a*. In shrinking, the lintel left the brickwork above it without any support, and this brickwork finally fell down on the lintel, making the crack as shown.

It will be noticed that there is also a crack at *d*. This crack was caused by the brick piers between the windows

used in the fireplace grates, the flue area may be made one-fifteenth of the area of the fireplace opening for the rectangular form, and one-eighteenth for the circular form.

24. Construction of Flues.—Fireplaces are frequently placed back to back on the same story. Where they are located immediately over each other, as in the upper stories, it is necessary to divert the upward direction of the lower flues either to the one side or to the other in order to avoid the niche for the fireplace above. The divergence should be gradual, and is best effected by the introduction of curves of large radii, thereby reducing the friction in the flues. The friction is considerable when sharp angular offsets are formed. The curved flues are considered preferable to those that are perfectly straight, in that they prevent rain and sleet from falling vertically on the fire, while they also tend to check the downward passage of currents of cold air, called *down drafts*. The divergence, to be effective, should be such that daylight cannot be seen when one looks up the flue.

Where it is impracticable to construct the flue with a deviating curve, and a vertical line must be followed, it will be found expedient to place a solid cover on the top of the chimney, and arrange for smoke outlets on the sides of the stack. This method of construction will prevent rain and sleet from descending into the chimney, and the walls of the flue will thus be kept drier than they otherwise would. It is quite necessary to exclude rain and snow from a chimney flue, as the presence of any moisture will seriously affect the draft.

25. The opening above the fireplace is contracted like an inverted funnel, or hopper, so as to guide the ascending current of heated air and smoke toward the inlet to the flue proper. This is shown in Fig. 13 (*a*), which is a view of a fireplace constructed in a brick stack, portions of the facing brick having been removed in order to show the construction. The funnel-shaped contraction *a*, called the *throat*, is formed by drawing over the brickwork at *b*, *b*, each course of brick adjacent to the opening being corbeled, or made to advance slightly in front of the course immediately underneath it.

The lower corners of the brick are cut off with the edge of the bricklayer's trowel, and the corbeling follows a curved outline up to the neck, or inlet, of the flue proper, as shown at *c*.

The effectiveness of a flue depends largely on the temperature of the gases flowing through it; therefore, the height of the opening over the fire should be restricted to, say,

(*a*)

Fig. 13

30 inches, so that the cold air from the room may not readily pass up the flue without first coming in contact with the fire.

26. In Fig. 13 (*b*) is shown a vertical section of the chimney illustrated at (*a*). The method of contracting the throat of the chimney transversely, just over the fireplace, as shown in (*a*) and (*b*) at points *d* and *d'*, respectively, is adopted with a view of preventing the influx of a large volume of cold air over the fire, which tends to form an eddy in the throat of the flue and thereby causes the smoke

and gases to be belched out in waves at the head of the fireplace into the room; this is especially so where there is not a regulating damper over the fire. The contraction may be formed by corbeling out several courses of brick, as at *e*, so that the width at *d* and *d'* may be 3 or 4 inches, according to the size of the flue, the contracted area being made about equal to the area of the flue. The ledge shown at *o* and *o'*, formed by the upper course of brick, also serves as a wind break in the case of down drafts, and diverts the swirling current upwards, as indicated by the arrow *g*.

27. Flue Linings.—In Fig. 13, the flue is lined with fireclay linings, as shown at *h* and *h'*. These linings are usually made in 2-foot lengths and should be carried up from the neck of the flue to the lower bed of the chimney coping. The holes in the coping are cut to correspond to the inner dimensions of the linings, so as to prevent the descent of rain water between the back of the lining and the brickwork.

28. The nominal sizes of fireclay linings do not usually express either the actual inner or outer measurements, but are simply approximate, as shown in Table III.

TABLE III

SIZE OF FLUE LININGS

Nominal Size Inches	Actual Outside Measurement Inches	Nominal Size Inches	Actual Outside Measurement Inches
4 × 12	4½ × 13	12 × 12	13 × 13
8 × 8	8½ × 8½	12 × 16	13 × 18
8 × 12	8½ × 13	16 × 16	18 × 18
8 × 16	8½ × 18		

The thickness of the linings varies from about ⅝ inch for the smaller to about 1 inch for the larger sizes. The 4″ × 12″ flue lining is an undesirable one, on account of its proportions, and, although sometimes used for flues for small fireplaces, its use is not to be recommended. The

square opening formed by the 8″ × 8″ lining will always justify its being adopted, and this size is large enough for ordinary fireplaces where anthracite is to be burned. Where wooden logs or bituminous coal is to be burned, the size of the flue should be appreciably increased, owing to the greater volume of smoke; therefore, the 8 in. × 12 in. or larger size is necessary.

29. Setting Flue Linings.—The flue linings should not be set in lime mortar, but in Portland cement or in fireclay, preferably the latter, for at least a distance of 15 or 20 feet above the fireplace, where the joints are likely to be attacked by the flames. Since the fireclay does not contain any fusible constituents, it is well adapted for the purpose.

In districts where the flue linings are not readily procured, the flues should be constructed with selected hard-burnt brick laid in cement mortar, the bed and butt joints being thoroughly filled with mortar. The joints on the inner surfaces of the flues should be neatly struck flush, so that they may be as smooth as possible and offer the least amount of resistance to the ascending column of air. They should not be plastered with lime mortar, however, as the action of the heat will soon cause it to crack, crumble, and fall off.

30. Where chimneys have to be constructed entirely of rubble masonry, the inner surfaces of the flues may be plastered with parget in order to obtain an even and smooth surface. Parget is a mortar composed of one part of lime, one part of sand, three parts of cow dung, and an admixture of goat or cattle hair. This mixture makes a tenacious lining, which well resists the heat and is less liable to crack than the ordinary lime mortar.

31. Sweepers.—During the formation of chimney flues, it is well to use a sweeper, which is a bunch of rags, or waste, inserted in the flue, so as to collect the droppings of mortar from the mason's trowel and prevent them from becoming attached to the sides of the flue. The sweeper is tied together with a strong cord, by which means it may be drawn up as the work progresses.

32. Construction of Fireplaces.—In Fig. 14 is shown the construction of an ordinary fireplace that is to be furnished with a grate and mantel. Assuming that the fireplace

Fig. 14

is on the first floor, an ash-pit is formed in conjunction with it in the cellar, so that the ashes from the grate may be readily discharged into it, and from which they can be removed at regular intervals.

As fireplaces generally require more depth than can be obtained in the thickness of ordinary walls, it is necessary to construct the stack of such additional thickness as may be required to accommodate the grate. The increased thickness may project either on the exterior or the interior of the wall. When the projection is made on the exterior, it does not reduce the size of the room and permits the construction of a straight interior wall surface.

33. In many cases, the exterior projection is so treated that the chimney throughout its height is emphasized and made to form a striking and effective feature. However, this is often sacrificed on the score of economy in the cost of execution, as when the projection is made on the interior of the wall there is little extra cost, and at times it is desirable to accentuate the vertical lines of the stack in the apartment.

The projection is called the **chimney breast**, and when treated on the interior its width *A*, Fig. 14, measured between the finished plaster angles, is generally made 5 feet, which is the standard width for ordinary fireplaces, the return *B* in this case being 8½ inches. The height of the fireplace opening at *C* is made about 30 inches from the finished floor line to the springing line of the arch, whose rise may be 3 or 4 inches. The width of the opening between the rough bricks, as *D*, should be 25 or 26 inches, and the depth of the niche *E*, from 12 to 13 inches. These measurements are subject to adjustment to meet the requirements of special grates and fittings.

34. At *a a* is shown an iron arch bar on which the rough arch is supported. The bar is made of ½″ × 3″ strap iron curved to suit the soffit of the arch, and has lugs turned up at each end, as shown.

At *b* is shown the ash flue through which the ashes are discharged into the ash-pit *c*, the floor of which may be kept up 2 feet from the cellar floor. This will allow the ash can *d* to be placed under the iron clean-out door *e*, facilitating the removal of the ashes and preventing the ashes from being

carried over the cellar floor. A niche is formed in the front wall of the ash-pit, allowing the body of the ash can to pass under the clean-out door.

The floor joists are framed so that the portion of the floor system in front of the fireplace is carried by the trimmer joists *f*, *f*, which, in the event of flues passing through the jambs in the fireplace, would be kept 2 inches clear of the brickwork. The header joist *g*, *g* carries the tail-joists *h*, *h*, and is supported itself by the trimmers *f*, *f*. The junctions may be made by mortising and tenoning them together, or they may be hung in stirrup irons.

A temporary wooden center *i* is placed to support the trimmer arch *j* during construction, the function of the arch being to carry the hearth free and clear of any woodwork. The depth of the arch is 4 inches.

Fig. 15

35. The extrados of the arch is leveled up with cement concrete, as shown at *k*, Fig. 15, preparatory to receiving the hearth, which may be a slab of polished slate or composed of plain or enameled tiling.

As a depth of 16 or 17 inches is necessary to accommodate the average grate, an additional 4 inches is built out as shown

at the jambs *l*, *l*, Fig. 15. A flat iron bar *m* is placed on these jambs, and three courses of brick are bedded on the same.

A hardwood border *n n*, 2½ inches wide, is run around the hearth, and is kept ⅜ inch above the floor where carpets are used, so that they may butt against it. The border may be a thin hardwood strip, as shown, but a more satisfactory finish would be secured if the border were made the thickness of the floor plus the ⅜-inch projection, and having a tongue on the outer edge, in order to keep the end surfaces of the flooring boards firmly in position.

36. In Fig. 16 is shown a view of the fireplace after the tile hearth *a*, the facing tile *b*, and cast-iron fireplace linings *c*, *c* have been set. The facing tile, about ⅝ inch in thickness, may

FIG. 16

be bedded in plaster of Paris against the rough brickwork, but it is more expeditious to mount them on slate slabs, as shown at *d*, *d*. They can be attached to the slabs in the workshop, so that they may be set up in one piece on the building.

The sizes of tiling generally used are: 1 1/16 in. × 4¼ in., 1½ in. × 4½ in., 2 in. × 3 in., 2½ in. × 5 in., and 3 in. × 6 in.

The tiling is glazed and manufactured in various colors, the tint being either uniform or finished with a graduated shade, which gives a certain amount of relief and variety not possessed by a monotone.

Mosaic of colored marbles is also used for the hearth and facing of the fireplace, in which material choice and intricate designs of ornamentation may be executed.

Fig 17

At *e* is shown one of the gas pipes let into the brickwork as it would appear before being covered with the finished plaster, the capped outlets *f*, *f* being set at the accurate height to suit the mantel design.

At *g* is shown the ash trap, which consists of a cast-iron frame and two pivoted iron shutters that are nicely balanced

so that they will drop and allow the ashes to pass through as soon as they fall from the grate. Ashes accumulating on the hearth beyond the limits of the trap should be swept into it. A brass cover, shown at *h* and *h'*, may be placed over the trap when the grate is not in use.

37. The completed fireplace is shown in Fig. 17, in which a mantel of Renaissance design encases the chimney breast up to the shelf line and forms a framing around the tile facing.

The outer dimensions of the grate front are usually 30 in. × 30 in., the width of its framing being from 1½ to 5 inches, according to the style selected, which thus regulates the height and width of the finished niche. A movable basket grate is shown in the niche; this grate is more popular than the brick-set grate. Movable dampers in the top lining regulate the draft. The top lining may be fitted with two sets of dampers, one adjacent to the back for direct draft when starting the fire, and one toward the front for use when the fire is under headway.

SETTLEMENT IN BRICKWORK

38. The settlement that occurs in brickwork is due to the shrinkage of the lime in the mortar joints as they dry out. This settlement is practically proportional to the number and thickness of the joints in the wall. Therefore, if the walls in a building are of a uniform height, they will shrink evenly, no matter how many windows and doors there may be in the structure.

There is another cause, however, that is not so easy to deal with. In this case, the shrinkage is caused by the settling of the joints due to the weight of the brickwork above. The more weight there is on a certain joint, the more the brickwork will shrink. Fig. 18 (*a*) represents a tall tower with a window opening in it. At (*b*) is shown a section through the tower on the line *a b*. Consider the tower to be divided by the line *f g*; then, an equal weight of

brick will bear on each side of this line. Because of the bearing area taken out by the window in the part *d*, however, there is less area to support the weight than there is at part *e*. Therefore, the pressure per square inch on the brickwork at *d* will be greater than the pressure per square inch on that at *e*, and the joints in the part *d* will compress more than the joints in the part *e*; consequently, the tower will settle unevenly and be out of plumb.

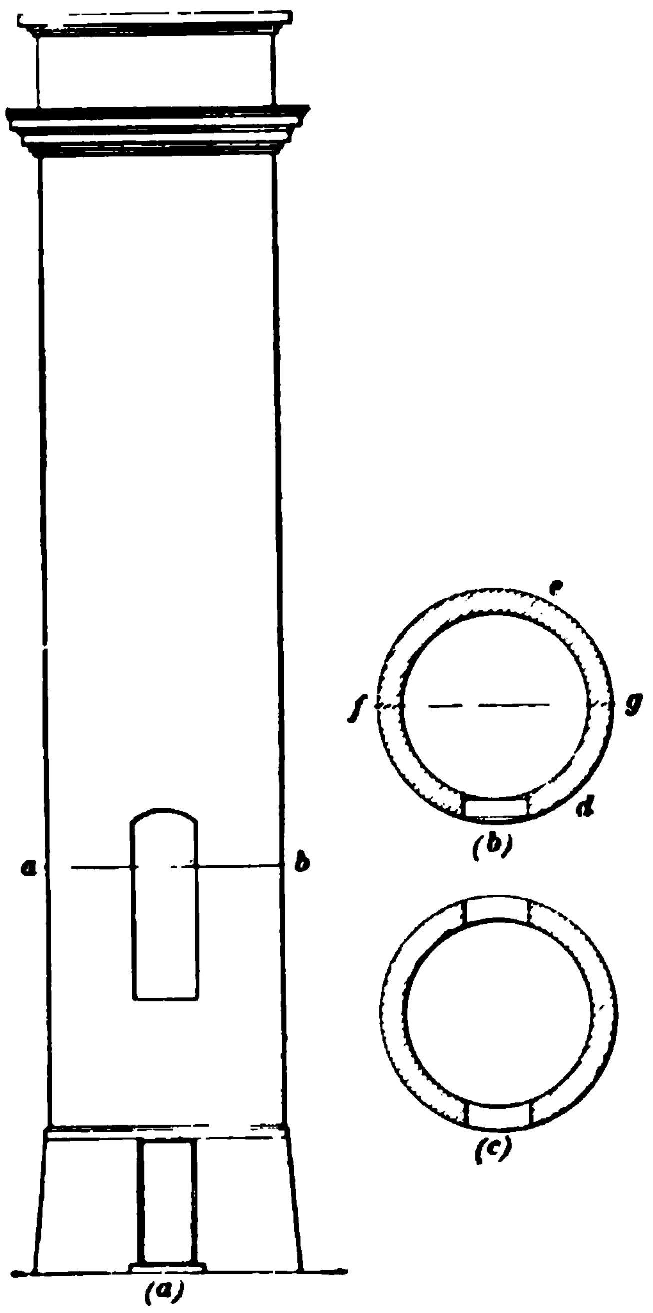


FIG. 18

39. In building a tower where it is desired to put in a window, two openings opposite each other are usually left in the shaft, as shown at (*c*). This method divides the load evenly on both sides of the opening, and allows the tower to settle uniformly throughout. Afterwards, if only one opening is required, the other one may be bricked up.

Of course, the amount of shrinkage is not always large except in a tall narrow building with a large opening in it, as, for instance, the flue opening in a brick smokestack, but nevertheless the shrinkage is sometimes enough to cause trouble.

40. There is another difficulty about placing an opening in a circular shaft, that is, the arch above the opening has no masonry in its line of action to take up its kick, or thrust. For this reason, the brickwork above an opening in a tower should be supported by a steel beam embedded in the masonry. Afterwards, an arch may be sprung in below the beam, but this arch is simply placed there for appearance, and the entire load should be carried on the beam.

DAMP-PROOF COURSES

41. When a building is erected on a wet site, the moisture in the ground has a tendency to creep up the walls by capillary attraction and dampen them. This dampness is especially noticeable in walls built of common brick, as they are more porous than other building materials. Moisture in the walls of a house will not only rot the woodwork, but will also become a menace to the health of the occupants.

To prevent moisture from rising in the walls of a building erected in very wet ground, a damp-proof course should be inserted. This course must run around the entire building and extend completely through the wall. It must be placed at as low an elevation as possible, but yet a sufficient distance above the ground to prevent water from entering the wall from above.

In many cases where buildings are finished with parapet walls, it is customary to put in a damp-proof course just above the flashing of the roof or gutter, in order that the dampness produced by driving rains may not soak down into the woodwork of the roof, and from there to the walls below.

42. Damp-proof courses may be made of hot asphalt and coal tar. They should be mixed in the proportion of nine parts of asphalt to one of coal tar, and put on in a $\frac{3}{8}$-inch layer, or the thickness of a mortar joint. The surface of brickwork that receives the asphalt should be quite dry and smooth, and the joints should be well flushed up with mortar.

Two courses of roofing slate or very hard vitrified brick laid with broken joints in sand-and-cement mortar form a cheap damp-proof course; or, a $\frac{1}{2}$-inch layer of Portland cement mortar mixed in equal proportions of cement and sand is often used.

A stone damp-proof course is also frequently employed, and although it will absorb water, yet it is less porous than brick. On the whole, however, asphalt probably makes the best damp-proofing.

ORNAMENTAL BRICKWORK AND TERRA COTTA

ORNAMENTAL BRICKWORK

COLOR DESIGNS OF BRICKWORK

1. Methods of Ornamentation.—There are numerous methods of ornamentation in brickwork, all of which are based on five principles of design. These principles are variation in the color of the mortar used; variation in the kind of bond used in laying the brick; variation in the color of the brick; variation in the shape of the brick, and the employment of such constructive features as pilasters, string-courses, water-tables, arches, and cornices. These methods can be, and often are, used in combination.

2. Not much can be said in regard to the color of mortar best suited for ornamental work of various kinds. Neither can definite rules be laid down, as the selection of the proper color is usually governed by the particular requirements of each case and is really a matter of taste or judgment, to be decided by the architect.

There are two general methods of getting desired effects, however. One is by a great mass of solid color, and the other is by making each brick appear separate and distinct. In the first case, the mortar of course is made the same color as the bricks, while in the second case, the mortar is made so as to contrast, usually being a lighter shade than the bricks. The bricks and joints thus form what is called the *texture* of

the wall. The joints in the face of the wall are then often made as wide as $\frac{3}{4}$ inch, in order to make the bricks stand out. In this case, as a rule, the face of the wall is not calculated to have much strength; therefore, the backing must be made strong enough to carry the load. Rough bricks always look more smooth when pointed with mortar of their own color.

FIG. 1

3. Ornamentation in bond is usually accentuated by the color of the mortar joints, by raised work, or by the color of the bricks themselves. Variation in bond is usually shown in belt courses and similar details in different-colored bricks or of molded bricks.

159 § 1

FIG. 2

An illustration of a quaint Dutch gable is shown in Fig. 1. Here the ornamental effect is obtained by a variation in the bond. The bricks along the sides of the gable are set at an angle with their ends normal to the roof line, while the remainder of the work is in Flemish bond. One advantage of this gable construction is that no bricks have to be cut to thin tapering edges. At *a*, *a* will be seen anchors to tie-rods that hold the gable in place. These anchors also add to the artistic appearance of the structure.

4. Fig. 2 represents a portion of a wall laid up in different-colored bricks. This arrangement can be greatly varied in color and design. The darker bricks in the illustration are enameled, or vitrified. They can be procured with the enamel burned into any side or end. The illustration is that of an ornamental frieze, but this kind of work may be used in many other places on a building, as will readily suggest themselves to the designer.

5. Another good example of effects that can be obtained by varying the color of the bricks, which is extremely plain, but neat, is shown in Fig. 3. This illustration shows a staircase in the Printery of the International Textbook Company, Scranton, Pennsylvania. The lower bricks are terra-cotta colored and have a rather shiny appearance. The joints between them are striped black. The upper bricks are buff colored, with joints that are striped white. The belt course is of dressed bluestone. This arrangement gives a wall that may be easily kept clean. On account of the semiglaced condition of the lower bricks, dust or the dirty hands of people going up and down stairs does not soil them.

6. Fig. 4 shows another color design of brickwork. The light-colored spaces are laid up in the form of sunken panels, and after the wall is finished, the panels are filled up with plaster of the desired shade, which is usually lighter in color than the surrounding bricks. This style of color ornament is cheaper than using enameled brick, although perhaps not so durable. The plaster filling is not always brought out flush

FIG. 3

150 FIG 5 § 41

with the brickwork but is sometimes left a little sunken to get the effect of the shadow on it.

7. Another method of ornamentation in color is shown in Fig. 5, which is made in imitation of the style used in the Museum Building at the University of Pennsylvania in Philadelphia. The light-colored pieces are made in different shades of marble. In some work, tile or *faience* is used instead of marble, and the designs are either painted or burned thereon. In work of this kind any slight variation in shade in the color of the bricks adds greatly to the attractiveness of the building.

BELT COURSES

8. Molded bricks are generally used in raised work. The architect is not necessarily governed by the bricks carried in stock, but may order any shape that is desired; yet it is cheaper and quicker to use some standard shape that is kept on hand at all times by the manufacturer or dealer.

Fig 6

The projection of the bricks in moldings, belt courses, etc. should be as small as possible to carry out the design, in order that the bricks may bond back into the wall. If the projection is too great, there is danger of the bricks falling out.

When practicable, and the projection is not too great, it is better to use more stretchers than headers in a belt course, because it takes a less number of stretchers than headers to run a given number of feet, and the cost of the bricks is therefore less.

9. Fig. 6 shows the best method of protecting the top bricks of belt courses from the weather. This is done by means of strips of sheet lead, which are built into the second joint above the belt course and turned down slightly over the face.

When it is not possible to use sheet lead to protect the top course, some other means should be adopted, for unless some precaution is taken to protect the top of the projecting bricks, rain water and frost will eventually destroy the joints and allow water to penetrate into the wall.

FIG. 7

10. A belt course of beveled bricks is shown in Fig. 7, where *a* shows the beveled bricks on top of the belt course, and *b* the coved bricks under the top course. The top course *a* should be laid as a stretcher course, provided that it does not project more than 3 inches from the face of the wall; this reduces the number of end joints in the brickwork. The bricks should be laid in cement, so that the mortar in

the joints will not be washed out. If the top course *a* is built as a stretcher course, the course *b* should have at least every other brick a header.

11. Another way of protecting a belt course consists in laying a beveled course of Portland cement, as shown at *a*, Fig. 8. This method is not considered as good as the

FIG. 8

other methods described, since the cement may become cracked and eventually fall off.

BRICK CORNICES

12. In buildings with flat roofs, the walls are often finished off with cornices of brick, terra cotta, or stone. Where any considerable amount of projection is required, the best plan is to adopt some corbel treatment, building the corbel up by slightly projecting each course. This mode of laying brick cornices is shown in Figs. 9 and 10.

13. Fig. 9 shows an arched and dentiled cornice, which is very effective in high buildings where a good shadow effect is desired without great projection. The cornice is shown in elevation at (*a*) and in section at (*b*). At *a* are shown the 4-inch arches, which are made of bricks laid the 4-inch way and sprung between the corbels. For very special work,

these bricks should be gauged, or rubbed, so that they will fit exactly in the arch. At *b* are shown the brick corbels, which are made 8 inches, or one brick, wide and seven courses high, each course having a projection of slightly over ½ inch; *c* shows the belt course, composed of two courses of bricks,

FIG 9

on which the corbels stop, the upper course projecting ½ inch; *d* is a dentil course of bricks laid as headers, with a 4-inch space between each dentil, which is two courses in height, each course projecting ½ inch; and *e* shows a galvanized-iron crown mold that can be used to form a gutter if desired.

14. In Fig. 10 is shown a less elaborate and cheaper brick cornice. The elevation is shown at (*a*) and the section at (*b*). The crown course *a* is composed of two courses of bricks; each projecting ½ inch. The corbels *b* are each 4 inches, or one-half brick, wide, and are spaced 4 inches apart; three of the courses in each corbel project about ¾ inch each, making the whole projection about 2¼ inches. At *c* is shown the belt course on which the corbels stop, laid in two courses of bricks, the lower course having a projection of 1¼ inches and the upper course setting back ½ inch

from the face of the lower course. At *d* is shown the dentil course of bricks set on edge, having a space between each dentil of $2\frac{1}{2}$ inches, or the thickness of a brick, and projecting 1 inch. The top of the belt course *c* should be protected

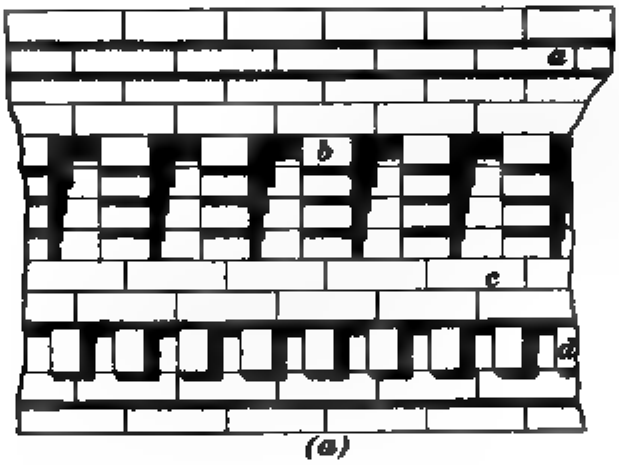


Fig. 10

from the weather by sheet lead, as shown in Fig. 6, or by Portland cement, as shown in Fig. 8.

15. A very effective brick cornice, especially for buildings of medium height, is shown in Fig. 11. This cornice

Fig. 11

bonds well, gives a strong shadow, and is easily laid. At *a* are shown the two top courses of brickwork in the cornice; the bricks are laid up as stretchers, the upper course projecting $\frac{1}{2}$ inch over the lower, and the lower course $\frac{1}{2}$ inch

over the dentil course. At *b* is shown the upper dentil course, projecting $1\frac{1}{2}$ inches over the lower dentil course; *c* is the lower dentil course projecting 2 inches beyond the lower belt course; *d* is the lower belt course of two courses of bricks, each one projecting $\frac{1}{2}$ inch; and at *e* is shown the galvanized-iron ogee crown mold, which may be used to form a gutter if desired.

BRICK ARCHES

16. When properly built, brick arches form one of the most secure spans for a door or a window, especially if the opening is wide. Arches should be laid up in cement mortar by careful and experienced workmen, or otherwise there is danger of the arches cracking and letting down the weight imposed on them.

17. Definition of Terms.—In order to obtain a better understanding of this subject, the following definitions of

terms used in connection with arches are given. They may be readily understood by referring to Fig. 12.

Span.—The distance between the abutments, as shown at *a b*. The word *span* is also used to mean the material construction that spans, or covers, an opening or a gap.

Springer, or Skew Back.—The stones or bricks that lie immediately on the imposts, as at *c*, *c*.

Spring Line.—A line drawn through the points where the arch intersects the abutments, or where the vertical supports of the arch terminate and the curve begins, as shown at *e d*.

Intrados.—The lower concave surface of the arch, formed by the under sides of the bricks, although considered by some authorities to be the concave line at the edge of the under side of the bricks.

Soffit.—The lower surface of the arch, or the intrados.

Extrados.—The upper convex surface of the arch formed by the outer sides of the bricks in the arch; also, considered by some authorities as the convex line of the curve of the outside of the arch.

Rise.—The perpendicular distance from the spring line to the highest point of the intrados.

Arch Ring.—The arch itself, contained between the intrados and the extrados.

Crown.—The highest portion of the arch.

Haunches.—The portion of the arch included between the crown and the skew backs.

Tympanum.—The space between the spring line and the intrados.

Spandrel.—The triangular wall space included between the extrados, a horizontal line drawn through the apex of the arch, and a vertical line drawn through the extremities of its extrados. The spandrel is shown at *z x y*.

Spandrel Filling.—The brickwork filling the spandrel.

Rowlock.—One of a series of arch courses, or rings. There is no bond between these rings other than that afforded by the adhesion of the mortar, as shown at *m*, *m*.

CONSTRUCTION OF ARCHES

18. Semicircular Arches.—When semicircular arches are constructed of common bricks, the bricks are laid close together on the intrados, with wedge-shaped joints on the extrados; that is to say, the mortar joints are wider at the upper surface of the brick ring than at the lower surface, so that there is more mortar at the top of the joint than at the bottom. The bed surfaces of the bricks are therefore not on radial lines, as they are in a gauged-brick arch, but the radial lines are assumed to pass through the center of each mortar joint.

Fig. 13 shows a semicircular arch consisting of four rowlock courses of brick. These arch bricks are all laid as

Fig. 13

headers, and show an 8-inch reveal on the soffit of the arch. The increase of the thickness of the mortar in the joints is much exaggerated in the illustration.

19. In arches of large span built of common bricks, especially in the brick lining of tunnels and vaults, the bond is often effected by building in headers, which will unite the concentric rings where the joints of two of the rings come together.

An example of this is given in Fig. 14, which shows an arch of four rowlocks, two being header and two stretcher

courses, the header and the stretcher courses being bonded by headers, as shown at *a*, *a*.

20. Skew Backs.—When brick arches of large span are to be built, they should in all cases have skew backs or springing stone, as shown at *b*, Fig. 14. The stone should be cut so as to bond into the brickwork of the pier, and the surface *c* from which the arch springs should be cut to a true radial plane.

21. Molded or Rubbed-Brick Arches.—When arches are built of common brick, the mortar joints become wider

Fig. 14

from the soffit to the extrados. It will be noticed by referring to Figs. 13 and 14 that there are more bricks in the outer rowlocks of the arches than in the inner rowlocks. This is, of course, due to the fact that the circumference of the outer circle is larger than the circumference of the inner circle. If an attempt were made to have continuous radial joints from the inside course to the outside course, in an arch of considerable thickness built up with common bricks, these joints would become very wide indeed at the extrados.

FIG. 15

FIG. 15

For this reason, either **molded** or **rubbed wedge-shaped bricks** are sometimes employed.

22. Fig. 15 shows a semicircular arch constructed of **gauged,** or **shaped, bricks.** The gauging, or shaping, may be accomplished by laying out the arch ring on a floor, and cutting, rubbing, or grinding the bricks to a certain gauge, or pattern, so that each brick will fit exactly in the place chosen for it; and all the mortar or radial joints will be of the same thickness throughout.

In the example shown in the illustration, the space under the arch is filled by a brick wall supported on a bluestone lintel. This allows the bronze doors underneath to be made square on top. A semicircular window would answer the same purpose as the wall.

As seen by the illustration, the extrados of the arch is stepped into horizontal steps. This is done so that the bricks in the wall will not have to be cut down to a knife edge in order to make them fit the work.

When the *reveal*, or space between a window or door frame and the outside of the wall, is only 4 inches, gauged-brick arches do not usually have any bond in the body of the wall; therefore, the bricks in the arch should be laid with great care and accuracy.

Gauged, or shaped, bricks are supplied by most of the extensive pressed-brick manufacturers, who prepare the bricks so that each one will fit accurately in its position in the arch. When these bricks are ordered from the manufacturers, either full-sized or large-scale drawings should be furnished, giving the span of the opening, the radius of the arch, and the depth of the reveal.

It will always be found that rubbed bricks, that is, bricks that are shaped after they are made, will fit better than molded bricks, or bricks that are first made wedge-shaped and then burned, because the latter are liable to become warped in burning.

23. In Fig. 16 is shown the arch at the main entrance to the Printery of the International Textbook Company. This

arch is of 12-foot span. It is made of rubbed bricks, which permit the joints to be uniform and narrow, as can be seen from the illustration. The extrados is not made into a regular curve as is customary, but is stepped up for artistic effect.

24. In Fig. 17 is illustrated an arch of molded bricks that is used in the interior of the same building. This arch is 9 feet and ½ inch span. Being an elliptic arch, it takes less headroom than would a circular arch. Although the arch in question was actually built with the intrados forming a perfect ellipse, a very close imitation of this curve may be had by making the intrados with five suitable circular arcs.

25. Brick Segmental Arches.—Fig. 18 gives an example of a **brick segmental arch.** The feature of

Fig. 18

this arch is that the intrados curve is less than a semicircle, thus making an angle with the line of the abutment instead of being tangent to it. It is a three-rowlock arch constructed entirely of common bricks laid as stretchers. This form of arch, unless bonded back into the rear wall with strap iron, is not a strong method of construction.

26. Figs. 19 and 20 are two more examples of segmental arches. The cross-bond is plainly shown in Fig. 19. The piers supporting the arch in Fig. 20 are corbelled out, as shown, to help carry the thrust. The extrados of this arch is made perfectly flat. The intrados is made on two surfaces, as shown. Both Figs. 19 and 20 show arches that are excellently made and are worthy of careful examination.

Fig. 19

28. Relieving Arches.—Instead of cambering, or curving, the under side of a flat brick arch placed over an opening, the soffit is often made flat and is supported on an iron angle bar. This form of construction is shown in Fig. 22, in which (*a*) is an elevation of a 12-inch flat arch over a window opening, the arch being supported on a $1\frac{1}{2}'' \times 1\frac{1}{2}''$

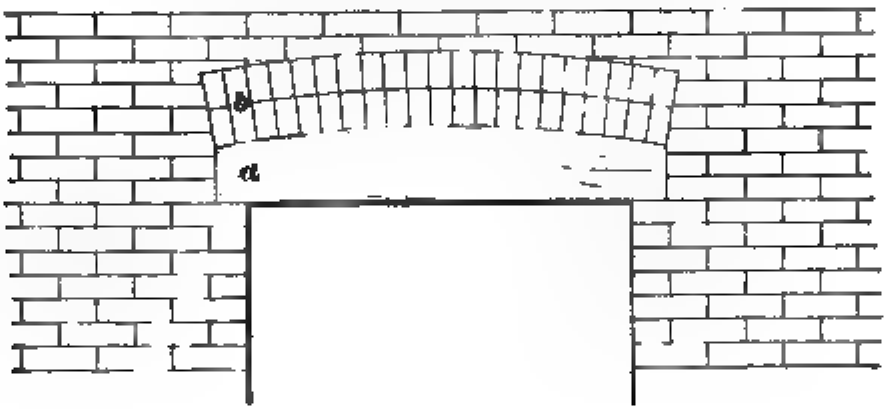


FIG. 23

$\times \frac{1}{4}''$ iron angle, as shown at *a*; (*b*) shows a section through the arch, *a* being the iron angle; *c*, the 4-inch brick arch; and *b*, the wooden lintel behind the arch.

29. Sometimes, when the construction will admit, the wooden lintel may be cut on a segmental curve, as shown in Fig. 23. In this sketch, *a* shows the 4-inch wooden lintel cut

FIG. 24

to the required curve, and *b* the two-rowlock brick arch resting on the curve of the lintel. This arch is called a **relieving arch**, because if there is any shrinkage of the wooden lintel, there will be no settlement of the brickwork, the arch carrying the weight of the wall placed on it. To prevent cracking, arches are usually built over stone lintels.

30. In some cases, the arch is turned over an ordinary lintel, with the spring of the arch starting from the ends of the lintel, and a core of brickwork is laid between the under side of the arch and the top of the lintel. This is shown in Fig. 24; *a* is the lintel, which may be either of wood or stone; *b* is the relieving arch, shown in this case as a two-rowlock arch; and *c* is the brick core between the lintel and the under side of the arch.

31. Lateral Thrust in Arches.—In all arches on which weight is imposed, there is a horizontal thrust, or kick, on the brickwork at each side of the arch. So long as the brickwork is strong enough to withstand this thrust, no damage can occur; but, if the arch is placed near the corner of a building a crack is liable to occur in the wall above the arch, unless provision is made to tie in the side wall by means of an iron beam or rod.

FIG. 25

Fig. 25 represents an arch near the side of a building where there is no strength in the wall to take up the lateral thrust. The crack *a* is the result.

32. Fig. 26 is an illustration of an arched doorway in the corner of a department-store building. This arrangement does not even satisfy the eye, because the arch is only a sham, the load above the doorway being carried by hidden beams or some other device. The arch has no strength in itself, as any weight on it would produce a thrust that would

push out the walls of the building. When an arch must be used in such a place, it should be stiffened with some form of beams put into it, or the two skew backs should be tied together. By using this latter method, of course the tie-rod

FIG. 26

would show inside the building. Then, also, the crown of the arch would have to be held back in place to prevent its falling forwards into the street. The best method, therefore, when it is absolutely necessary to use such an arch, is to carry the load of the superimposed brickwork on hidden beams.

BRICK VAULTS

33. A **vault** is shown in Fig. 27. It is simply an arch that is long in the direction of its axis. Vaults are constructed in

FIG. 27

FIG. 28

the same manner as arches, with the additional precaution that the bricks are bonded longitudinally, as shown in the figure.

34. Groined Vaults.—An example of an **intersecting, or groined, vault** is shown in Fig. 28. This style of vault is often used, although it probably cannot be built as strong as the one shown in Fig. 27, because its strength at the groin *a b* depends entirely on the bond in the brickwork.

35. Brick-and-Concrete Vaults.—Vaults formerly were built of brick arches, called **armatures**, with concrete filling. This form of construction is good, and is quite easy to erect. An example of such a vault is shown in Fig. 29.

FIG. 29

CLEANING AND PROTECTING BRICKWORK

36. After a building constructed of pressed brick is finished and pointed, it should have its walls cleaned down. Any mortar that has adhered to the walls may be easily removed with a stiff scrubbing brush. To take out mortar stains, the walls are washed with dilute hydrochloric acid in the proportion of about one part of acid to twenty parts of water.

EFFLORESCENCE

37. Very often, on buildings of stone or brick, more particularly the latter, white stains will appear on the surface of the walls after a few days of wet weather. These stains are called **efflorescence**, and are due to one or more of the following causes: (1) The water used in making the mortar dissolves salts of potash or soda from the brick or stone, and when the water evaporates these salts are deposited on the surface of the wall; (2) the soda in the brick is drawn out by capillary attraction; (3) the clay in the brick contains iron pyrites or else is burned with sulphurous coal, thus forming sulphuric acid, which combines with the magnesia in the lime to form a white salt; (4) the clay of which the bricks are made sometimes contains soluble salts, which are dissolved by rains and deposited on the surface of the brickwork.

38. This discoloration can be prevented if boiled linseed oil is applied to the wall every 3 to 5 years in the same manner as paint is applied with a brush; and efflorescence can be removed by washing the walls with dilute muriatic or nitric acid. A well-known authority has recommended as a preventive that to every barrel of cement used in making mortar should be added 100 pounds of quicklime and 10 pounds of animal fat. This last method does not always prevent efflorescence but merely makes it less noticeable and is seldom used today, although it was at one time employed to some extent.

PROTECTING THE OUTSIDE OF BRICKWORK

39. After a driving rain or a sleet storm, a wall even as thick as 12 inches may be wet through. It is therefore not desirable to plaster directly on the walls, as ordinarily the plaster and the wallpaper will be spoiled; if it is necessary, however, to plaster directly on the brick, the wall should be made waterproof, or built hollow. If this cannot be done, the wall must be furred with $1'' \times 2''$ furring strips, though the last method does not prevent the moisture coming through the wall itself.

40. Waterproofing.—There are two methods of waterproofing brickwork. The first is to paint it with oil colors, and the second is to coat it with hot asphalt. Either method, of course, will spoil all the beauty of the bricks, and is not to be recommended except in extreme cases. If either of these methods is used, however, the wall should be thoroughly dry before the application. If asphalt is used, it should be put on while hot.

A few coats of boiled linseed oil will usually keep out moisture for 2 or 3 years, and will not injure the color of the bricks.

41. Sylvester's Process of Waterproofing.—One of the best methods of waterproofing a wall, which also prevents efflorescence, is known as **Sylvester's process.** The wall is coated with two solutions. First, a solution of Castile soap in water is applied while boiling hot, care being taken that it does not froth. After this coat has become thoroughly dry, a coat of alum and water at an ordinary temperature is put on. These coats applied in the manner just described form an insoluble compound, which enters the pores of the bricks and makes the wall waterproof. In extreme cases, it may be necessary to repeat this process, but usually one coat of each will suffice.

There are also several patent waterproofing compounds on the market. Probably the best two of these are Duresco and Cabot's Brick Preservative.

TERRA COTTA

VALUE IN CONSTRUCTION

42. The uses of terra cotta in architectural work are so varied and extensive as to be almost endless. Both for inside and outside decorative and plain work, it forms a very important substitute for stone and brick, especially in positions exposed to the weather.

Although terra cotta has come into extensive use within a comparatively recent period, it has met all requirements very satisfactorily, showing itself to be of the utmost value as a durable building material. In Europe are to be seen many examples of terra cotta that have endured the changes of the weather for hundreds of years and yet remain in good condition, while stone similarly exposed has become more or less disintegrated.

The great value of terra cotta for building purposes consists in its durability. If made of the right kind of materials, and properly burned, it is practically impervious to moisture, and hence is not injured by frost, which is such a powerful destructive agent in many building stones. Atmospheric gases, likewise, have no effect on well-burned terra cotta, and dirt gathering on it is easily washed away by rain. Another point of value is that it affords no lodgment for vegetable growths, as do some stones. When terra cotta is not sufficiently burned, it lacks the proper surface vitrification, and is then to some extent absorbent, and, consequently, not so durable. The heat-resisting power of terra cotta is also of importance, and makes it a very desirable material to use for trimmings and ornamental work in fireproof buildings.

43. Economical Advantages.—The cost of terra cotta varies according to the size and amount of work required.

Plain sills and caps can be obtained at about the same price as those of dressed sandstone, when the price of the rough stone does not exceed 90 cents per cubic foot. When many pieces of the same size and shape are required, terra cotta can be had much cheaper than stone, unless the charges for transportation are very high. When there are many molded and decorative features that would necessitate much hand work for dressing and carving if stone were employed, the advantage of using terra cotta in point of cost is evident. Further economy may be obtained by repeating the detail of the ornamental features, so as to require the fewest possible different pieces. Very often suitable designs may be found in catalogs of terra-cotta manufacturers, by using which the cost will be considerably less than when new patterns and molds must be made for the work. Another advantage is that terra cotta weighs less than stone, and, consequently, when the former is extensively used, lighter walls may be made than if the work were wholly of stone.

MANUFACTURE OF TERRA COTTA

44. The material in terra cotta is practically the same as that in brick, but a much better quality of clay must be used, and the method of manufacture is also different from that of brick. The proper selection of the materials used requires considerable skill and knowledge of effects to secure desired results. The clays used are obtained from different places, and must be mixed in proper proportions in order to obtain certain results. Much artistic skill is necessary to produce the elaborately decorated work now so common; consequently, terra-cotta manufacture ranks much higher than brickmaking.

45. After the clay is mined, it should be seasoned by exposing it to the air for some time. It is then ground and mixed with water and materials known as *grog*, which, in burning, produce a partial vitrification, thereby increasing the durability of the terra cotta. Grog usually consists of

very fine white sand, pulverized firebrick, partly burned clay, and fragments of pottery. The mixed clay is then piled in layers, each quality being kept separate. Ten or twelve strata are laid, and the mass is cut up into sections and again thoroughly mixed by being run between rollers, or through a pug mill, the object being to secure a complete and uniform mixture of the ingredients. The plastic clay is then formed into cakes of convenient size for handling, and is ready for the molder.

If only a single piece is wanted, the clay is modeled directly into the required shape, no molds being used. When, however, numerous pieces of the same size and shape are to be molded, a full-sized model of plaster and clay is made, from which a plaster cast is taken; this is thoroughly dried before being used. The tempered clay is compacted into the mold and allowed to become partially dry; it is then taken out and sent to the carver or modeler if it requires decoration, or to the clay finisher if it merely needs "touching up," or trimming. The unburned terra cotta is next removed to the drying floor, which is kept at a temperature of between 70° and 80° F., and is dried thoroughly. It is then ready for the kiln, in which it remains about 7 days for burning and cooling. In the burning an efflorescence is formed, which, on cooling, becomes hard and vitrified, rendering the material more durable; this glaze should not be broken unless it is necessary to do so.

46. Terra cotta is often made into blocks. To economize material and to prevent the blocks from becoming distorted and out of line, they usually consist of an outer shell braced by partitions about 1 inch thick. These partitions should not be more than 6 inches apart, and should be perforated, so that the mortar will form a good bond between the pieces.

Owing to the improvements in methods of manufacture, terra cotta may now be had in almost any shade, from nearly pure white to a deep red; but previous to about 25 years ago, most of the terra cotta produced had a red color. The shades

most commonly used at present are tints of gray, white, bronze, and red. Any color may be produced by chemical means, but a better quality of material is likely to result if those colors are used that are natural to the clay, and that do not require overburning or underburning of the clay to produce the desired effect.

CONSTRUCTION DETAILS

47. Size of Pieces.—In designing any terra-cotta work, care should be exercised to limit the size of the pieces to the most practical and economical dimensions; these may be said to be under 3 ft. × 4 ft. × 18 in. Columns have been made 14½ feet in length, the shaft being in one piece 12 feet long, but such sizes are very costly, as great skill and care are necessary in their manufacture to prevent warping.

Window openings of more than ordinary width should not be spanned by single pieces of terra cotta. Sills are usually formed of blocks not over 2 feet long, and the height of the pieces composing the jambs should not be more than 12 inches. In fact, all the work should be divided into as many pieces as possible, care being taken to insure proper bonding. Short lengths are more easily handled and less liable to break than long ones. When brick structures are trimmed with terra cotta, it is essential that the pieces be of the same height as the courses in the brickwork, in order that they may bond well into it.

48. As considerable time and extra expense are involved in manufacturing special shapes of terra cotta, such standard forms and sizes as may be readily obtained should be used whenever possible. When, however, the pieces must be made to order, the drawings should be sent to the manufacturer at least 2 months before the terra cotta is needed, so as to allow ample time for manufacture and delivery. While small pieces may often be obtained in less time, it is not advisable to force the work, as it increases the cost greatly and, besides, prevents the blocks from drying thoroughly.

49. Weight and Strength.—Solid blocks of terra cotta will weigh about 120 pounds to the cubic foot. Hollow pieces with walls $1\frac{1}{2}$ inches thick will weigh from 65 to 85 pounds per cubic foot, small pieces being heavier per cubic foot than large ones. An average weight for blocks 12 in. × 18 in. or larger on the face is 70 pounds per cubic foot.

Two-inch cubes of terra cotta will crush under a weight varying from 5,000 to 7,000 pounds to the square inch. Authorities give the safe working strength of terra-cotta blocks in the wall at 5 tons per square foot when unfilled, and 10 tons per square foot when filled solid with concrete.

50. Setting and Pointing.—Before using, each piece of terra cotta should be carefully inspected. It is important that abutting surfaces match perfectly and that each piece fits exactly in its proper place. Terra cotta should give out a clear, metallic sound when tapped with a hammer; and a fracture should show a close and homogeneous texture and uniform color. The surface should be hard enough to resist a knife scratch. Pieces that are broken or twisted or have the glazing chipped off should not be used.

The mortar used in setting terra cotta should be composed of good cement and sand, mixed in about the proportion of 1 to 2. The method of laying the blocks is similar to that of setting stone, and is generally done by the bricklayer, the terra-cotta work being carried up simultaneously with the brickwork. The blocks should be solidly built into or firmly anchored to the walls, and all voids should be filled with brick and mortar, to make the work as strong as possible. Immediately after the pieces are set, the face joints should be cleaned out at least $\frac{3}{4}$ inch in depth, so as to prevent the edges of the blocks from spalling, and to make ready for pointing. The mortar in all horizontal joints exposed to the weather should be raked out to a depth of 2 inches, and the joint should be calked about 1 inch deep with oakum, the remaining space being pointed in the usual manner. The pointing mortar should be made of about one part each of cement and sand, and colored to correspond with the terra cotta.

51. Terra-Cotta Casings for Girders.—In Fig. 30 (*a*) and (*b*) are represented two common forms of terra-cotta

(*a*)

(*b*)

Fig. 30

casings for girders that extend below the floorbeams. These

Fig. 31

are made of solid porous terra cotta; when dense terra cotta is used, it is best to make them hollow. The blocks are held

in place by clamps, or ties. This use of terra cotta is really for fireproofing and will be treated more fully in *Fireproofing of Buildings*.

52. Terra-Cotta Window Sills.—When window sills are made in sections, they should have lap joints, as represented in Fig. 31, in which *a* shows the pieces of terra cotta; *b*, the joint, which is protected by the half-round roll *e*; *c*, the wood sill of the window; and *d*, the joint between the terra cotta and the wood. This is a very good method of construction, as the insertion of the terra cotta under the wooden sill prevents water from penetrating the wall during driving rains.

53. Terra-Cotta Doorway.—Fig. 32 represents a good example for terra-cotta work, showing the accuracy and neatness with which the pieces may be manufactured and laid. The figure represents a doorway, *a*, *a* being the casing, and *b* the lintel, which is formed of several pieces that are joined as shown at *c*, *c*.

54. Terra-Cotta Cornices.—Terra cotta is extensively used for the cornices of buildings, as it is much lighter and usually cheaper than stone, especially if the work requires elaborate decoration. In order to balance a stone cornice during erection, it is always necessary that the projection of the pieces composing the cornice shall be less than the portion extending into the wall. A terra-cotta cornice, however, does not require this, as the various pieces may be made to enter the wall only from 8 to 12 inches, being held in place by ironwork embedded in the masonry. Small angles or I beams are generally used to support the projecting pieces of a cornice. If the projection is considerable, the inner ends of the beams should be anchored by rods carried down into the wall until there is enough masonry above the anchor to insure stability. When the wall carrying the cornice is light, a good plan is to anchor the top of the wall to the roof timbers, so as to prevent it from inclining outwards. If iron is to be used for tying the cornice to the wall, it is necessary to determine the method of anchoring before the pieces are

Fig. 32

35

Fig. 32

molded, as, in manufacturing them, holes or slots must be made for inserting the beams, rods, and anchors.

55. The method of placing and anchoring terra-cotta cornices is shown in Figs. 33 and 34. In Fig. 33 is represented a cornice having a projection of 2 feet. At *a* is shown the bracket extending into the wall, and held in place by an iron rod *b* bolted to the angle *c*, which runs longitudinally through the wall; the rod *b* has an anchor plate at its lower end.

Fig. 33

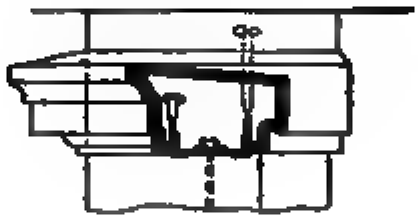


FIG. 24

In Fig. 34 is shown another cornice having considerable projection; *a* shows the bracket; *b*, the crown mold; *c*, a tie or clamp holding the upper portions of the cornice; and *d*, *d*, anchor rods tying the various portions of the cornice to the wall. There are, of course, many other designs of cornices that may be made, but they all act on the same principle.

LIGHTING FIXTURES

HISTORY OF ILLUMINATION

PRIMITIVE ILLUMINATION AND DEVELOPMENT

1. The methods and agencies of illumination are various, and have changed and improved with the progress of time. The earliest known method of obtaining artificial light was that used by primeval man, and was obtained from what is now called a bonfire, which was produced by means of sparks generated by the friction between two rapidly revolving pieces of dry wood, the sparks being nursed and fed into flame.

It is not supposed that these fires were transported from place to place, but undoubtedly our ancestors carried fagots, lighted at these fires, to dispel the surrounding darkness or to light other bonfires, thereby establishing a system of artificial illumination by torches. As mankind grew older and civilization advanced, the wooden torch gave place to the rush candle or rushlight.

The rush is a grass-like herb having a long soft stem; this stem was first peeled to the pith, except one strand (which was left to hold the pith together), and then soaked with the fat of animals or dipped into fish oil. With this light originated the first ornamental and essential appliance for holding or supporting the means of illumination: a notched stick supported on a wooden base.

The next step was the substitution of woven-cotton strands, or wicks, for the rush stem, and the burning of animal fats, pitch, and wax at the end of these woven-cotton wick

ends in open metal or earthenware vessels, as shown in Fig. 1, the illuminant being drawn through the wick to the flame by capillary attraction. This is the prototype of the lamps as now known. With this new method of illumination, it became incumbent on the maker to evolve some method of abating the noxious smoke and disagreeable odors attending the burning of these primitive lamps and to increase the field of illumination, which was very limited on account of the closeness of the flame to the body of the lamp.

Fig. 1

Fig. 2

The first of these imperfections was partly remedied by distilling oil from animal fats and then adding rich perfumes to the product, thus causing the oil to burn with less resulting soot and with the odors disguised by the perfumes. The other imperfection of the primitive lamp was gradually obviated by raising the wick end, as shown in Fig. 2. The number of lights was often increased to two or three, and a cover was placed over the reservoir with a small hole left in the top for filling.

2. The Candle.—The candle was also used at a very early period, though probably not as early as the lamp. In the candle, the mass of wax, stearin, or paraffin takes the place of the animal fat or fish oil of the rushlight and the reservoir of oil in the lamp, and gives the distinctive name to the different kinds of candles. In later years, the candle, because of its cleanliness, great practical adaptability and freedom from odor during combustion, became the chief source of light in the homes of the well to do.

3. The Kerosene or Modern Lamp.—The type of lamp shown in Figs. 1 and 2 was used in an improved form

up to the end of the 18th century, when rapid improvements began to be made and continued throughout the 19th century, resulting in the kerosene lamp of the present day.

Kerosene, which is a product of petroleum, is burned at the wick end in receptacles manufactured for that purpose, having the flame protected from draft by a glass chimney, which rests on a perforated base through which air is supplied beneath the flame to aid combustion. The wick has changed from the solid-rope form of the primitive lamp to the flat-ribbon or hollow-cylinder forms, and the light is reflected down or about the lamp, or both, by suitable shades or reflectors.

4. Gas and Electricity.—Next in order in the development of lighting came illuminating gas, and later electricity, both within the 19th century. These two are the methods of illuminating now most generally used and the appliances here considered are those used in connection with them.

ILLUMINATING APPLIANCES

GAS AND ELECTRIC FIXTURES

INTRODUCTION

5. The appliances employed for lighting buildings with gas and electricity may be divided into five groups; namely, *brackets*, *pendants*, *lanterns*, *chandeliers*, and *standards*. They are usually specified in the gas-fitting or electric-lighting specifications and are furnished and fitted by the gas-fitter or electrician. Frequently, however, the owner of a proposed building selects the fixtures, and then it is customary for the architect to state in the specifications that the fixtures will be furnished by the owner and placed by the gas-fitter or electrician. This plan gives the owner an opportunity to see his building finished, grasp the treatment of the interior finish, and then, with the advise of the architect, intelligently

select designs appropriate for and in harmony with the finished structure. Gas and electric fixtures are purchased from manufacturers or supply houses, and are never made by gas-fitters or electricians—who simply fit and place them.

Fixtures to match the interior decorations, trim, etc. are sometimes especially designed, and as the factories are generally located at a considerable distance from the work being erected, it is well for the designer to have some knowledge of the methods of manufacture and construction of gas and electric fixtures, otherwise his drawings, although beautiful in design, may not be practical. Manufacturers are very often compelled to change designs slightly so that the fixtures can be built within reasonable cost. If a designer knows what can and what cannot be made, and draws his fixture designs accordingly, he will be able to incorporate the proper treatment in the design without any danger of the design being altered and mutilated at the factory.

6. Fixture Terms.—A fixture that is made for gaslight only is called a **gas fixture,** or a **straight-gas fixture,** which means that there is no electric lamp or wiring in connection with it.

A fixture that is made for electric light only is called a **straight-electric fixture.**

A fixture that is made for both gaslight and electric light is called a **combination fixture,** or a **gas-electric fixture.**

BRACKETS

7. Stiff Brackets for Gas.—A **bracket** is a fixed or movable arm attached to a vertical surface and can provide illumination from one or more points; in the latter instance, several arms to support the different points of illumination are placed on one body. The component parts of a gas bracket, shown in Fig. 3, are as follows: The *bracket back* is at *a* and is usually a spun metal shell to cover the hole around the gas outlet on the wall. In designing this part, a careful designer will take into consideration any rough or

unsightly space around a gas outlet and arrange the size accordingly. The *stiff joint* is at *b* and is made of either bar metal or cast metal; it is drilled and tapped to fit the gas outlet and cock. The *cock* is at *c* and is fitted with a key that serves to regulate the flow of gas to the tip. The *arm* is at *d*, and is made of iron pipe, as at *h*; it screws into the cock fitting and into a tapped socket of the end fitting *e*. The iron-pipe arm is usually covered with a brass tubing *d*. The *end fitting e* of the arm is generally in the form of an elbow, as shown, and changes the flow of gas from the horizontal to the vertical direction. The *pillar f* and the end fitting are always made of brass tapped ⅜ inch, and the *tip g* surmounting the pillar is made of fire-hardened clay, being commercially called a *lava tip*.

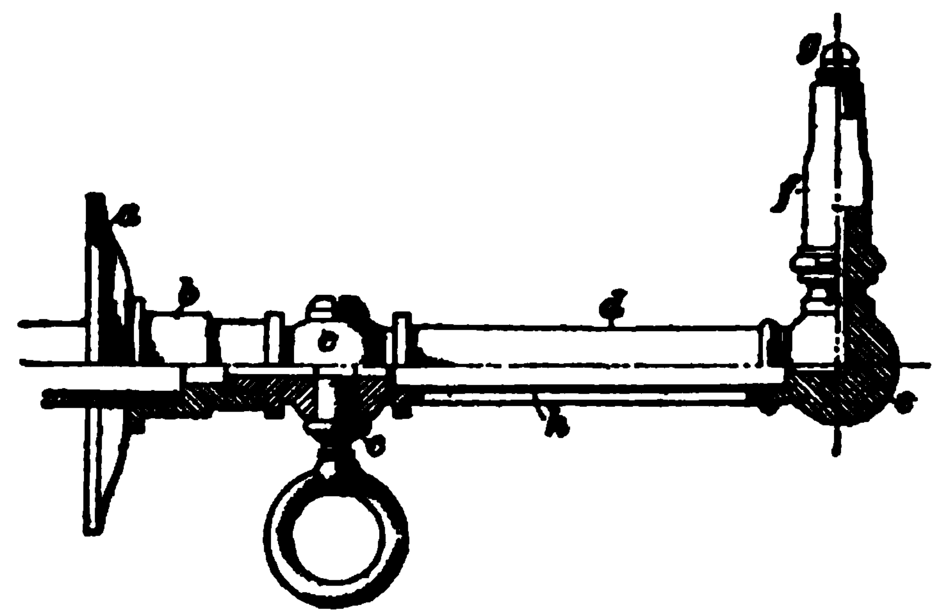


FIG. 3

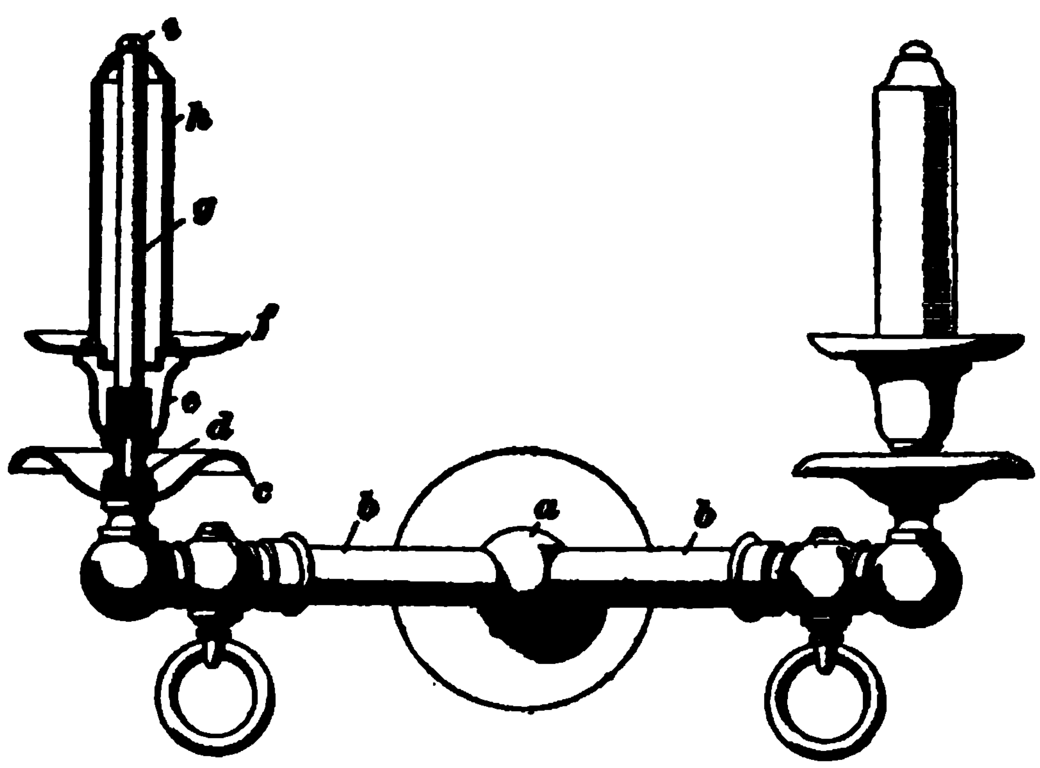


FIG. 4

8. In Fig. 4 is shown a **two-light bracket** with two cocks and with pillars of porcelain formed to imitate candles. The parts of this bracket may be described as follows: The *body a* is turned of bar metal or is a metal casting, and is

tapped in the center at the back to fit the stiff joint and at the two points in front for the arms. The *arms*, as shown at *b*, are usually of brass or bronze tubing, which is as practical for gasways or arms as iron pipe. The cock employed in the construction is termed an **L** *cock*, being combined in this

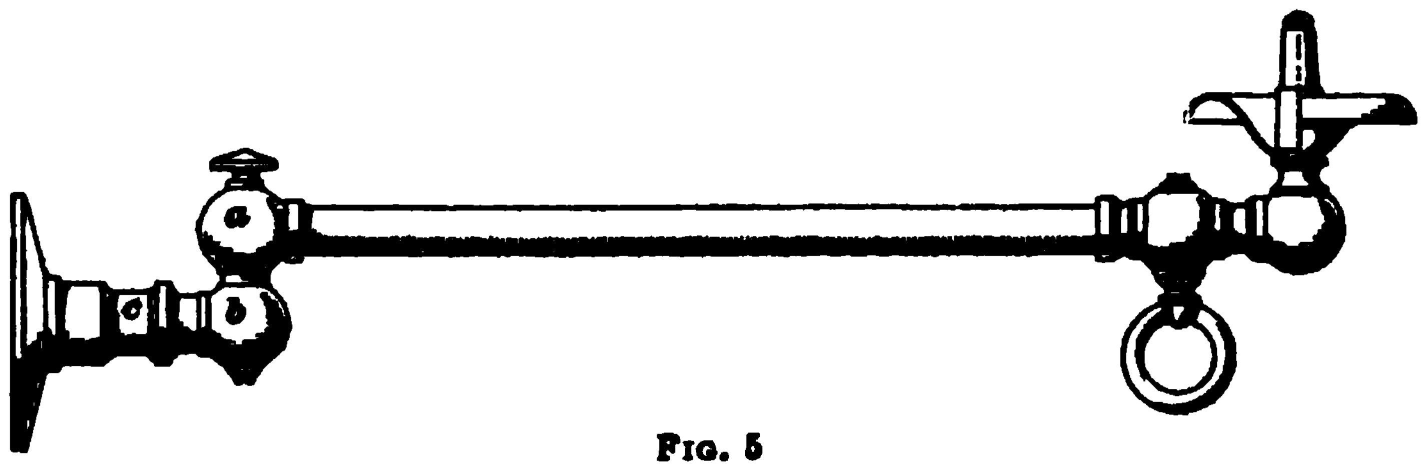


FIG. 5

instance with the end fitting. The *pan c* surmounting the end fitting is of spun shell or cast metal. The *neck d* is of brass tapped $\frac{3}{8}$ inch and is screwed to the end fitting, thus serving to hold the pan in position. The *candle socket e* is of spun metal shell or is a metal casting, and is held in position by the *candle tube g*. The *glass bobeche f* is passed down

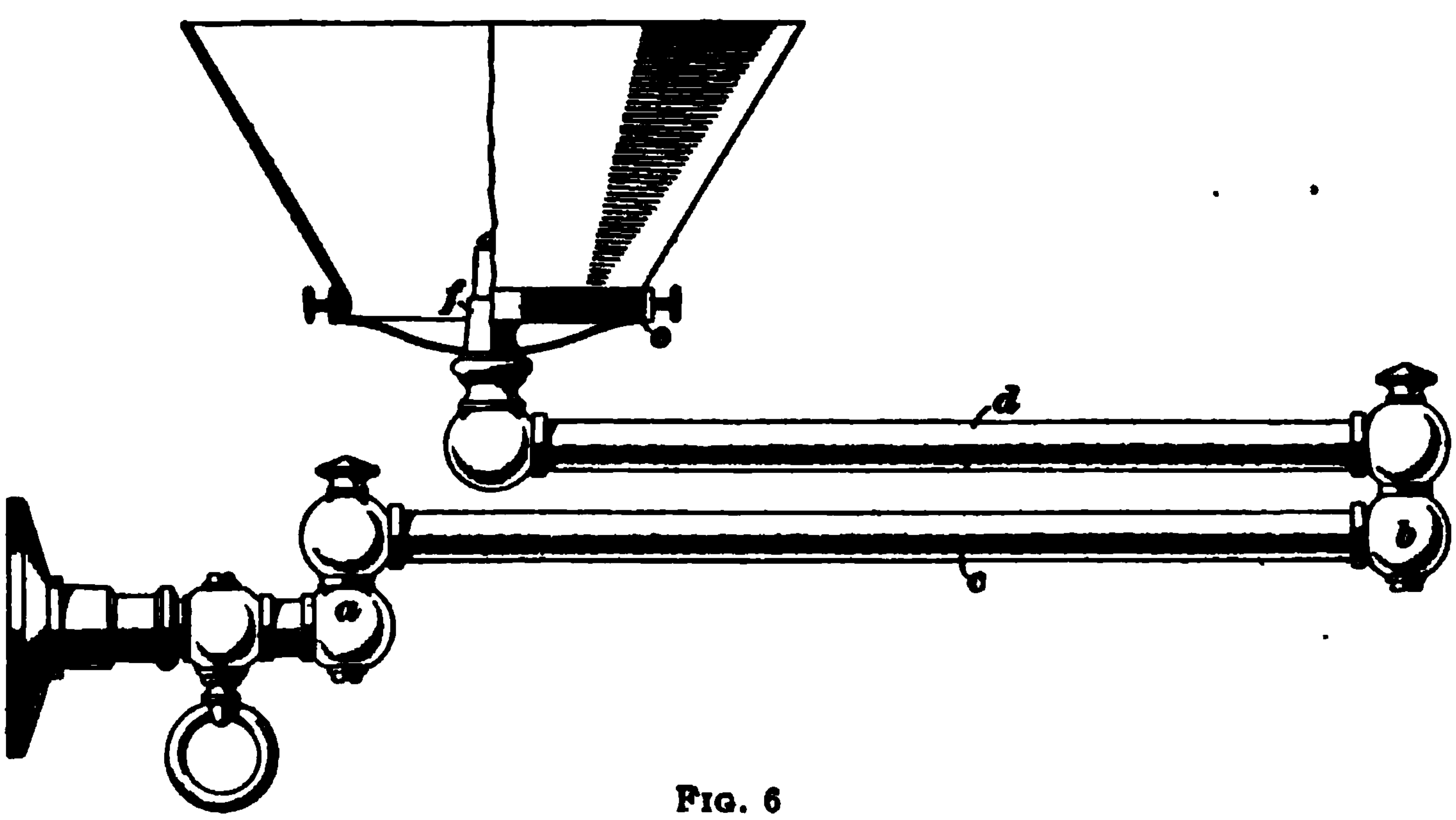


FIG. 6

over the candle tube *g* and rests on the candle socket *e*. The candle tube *g* is made of brass pipe tapped $\frac{3}{8}$ inch and is screwed to the neck *d*, thus holding in position the candle socket *e*, the glass bobeche *f*, the porcelain candle *h*, and the tip *i*.

9. Movable, or Swing, Brackets.—The **movable, or swing, bracket** is similar in construction to the stiff brackets, with the exception that a swing bracket includes a turned metal swing fitting at the end of the stiff joint *c*, which allows the bracket arm to swing freely in a horizontal direction. This fitting is shown at *a b*, Fig. 5.

As shown in Fig. 6, **double-swing brackets** combine two turned metal swing fittings in construction—one at the swing joint *a* and one at the end *b* of the lower arm *c*. The top, or upper, arm *d* is made 2 inches shorter than the lower arm, and is fitted with a globe holder *e*, which is held in position by the pillar *f*.

10. Brackets for One Electric Light.—As the current for electric lights is supplied through wires, an opportunity is given for greater freedom in designing fixtures than is possible where gas is used. Electric-light brackets similar to the one shown in Fig. 7 are only adapted to illumination where the connection with the wires is made through wooden walls. In the figure, the *bracket back a* is fastened to the wooden blocking by three screws and it acts as a tripod in serving to hold the bracket in place. This bracket back is made of cast metal, and must be of sufficient depth to permit the necessary connections to be made. The *arm b*, which is made of metal tubing not less than $\frac{3}{8}$ inch in diameter, is fitted to the bracket back and capped with a $\frac{3}{8}$-inch brass *end fitting c*; this fitting supports the *socket d*, and the incandescent lamp *e*.

In Fig. 8 is shown a bracket that is to be connected with the wires through a junction box in the wall, but not shown in the illustration. Junction boxes are used for the purpose of having proper insulation at the outlet, and if properly

installed they prevent the contact of the wires with the steel or iron used in buildings. In the event of contact, the current would become either grounded or short-circuited if the junction box and insulating joint were not used.

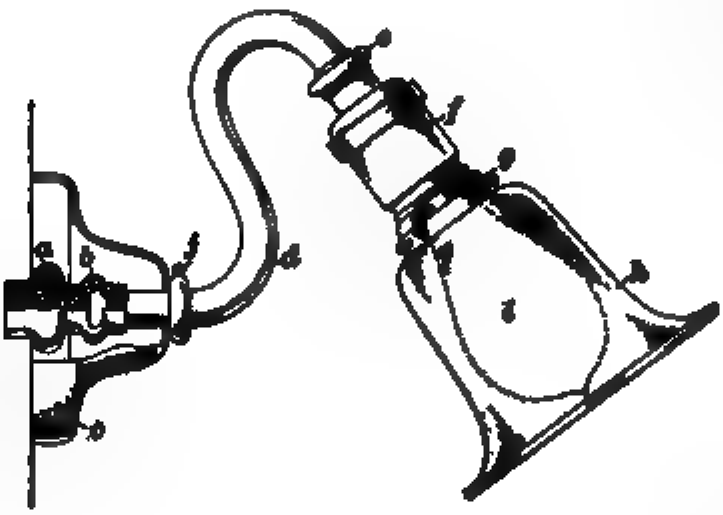


Fig. 8

The component parts of an ordinary electric bracket like that shown in Fig. 8 are: insulating joint *a*, hickey *b*, bracket back or canopy *c*, arm *d*, end fitting *e*, socket *f*, shade holder *g*, shade *h*, and lamp *i*, shown by dotted lines.

The *insulating joint*, which is shown in detail in Fig. 9, is a cast-iron coupling that connects with the junction box and serves to insulate the fixture from the iron work of the building, so that the effects of a short circuit in the fixture will not be communicated to the building. In the interior of the insulating joint is a bed of mica, or isinglass *a*, which is an

Fig. 9 Fig. 10

insulating material and also serves to hold the nipple *b* in position. The hickey *b*, Fig. 8, is connected with the insulating joint by a screwed joint. The middle globular part of the insulating joint is covered with a thickness of vulcanized rubber, as shown at *c*, Fig. 9.

The *hickey*, which is made of cast iron, acts as a coupling in connecting the arm with the insulating joint, and, as

shown in Fig. 10, is somewhat similar in shape to the insulating joint. It is provided with holes on the side of the middle part through which the wires for connection are passed, and prevents the wires from being bared, or abraded, while being fished through, thereby eliminating the possibility of grounding or short-circuiting the current.

As shown in Fig. 8, the *bracket* is furnished with a sliding back *c*, which can be placed anywhere on the arm of the bracket necessary to give freedom in making connections at the wall, after which it is brought against the wall and secured in place by a setscrew *j*, Fig. 8.

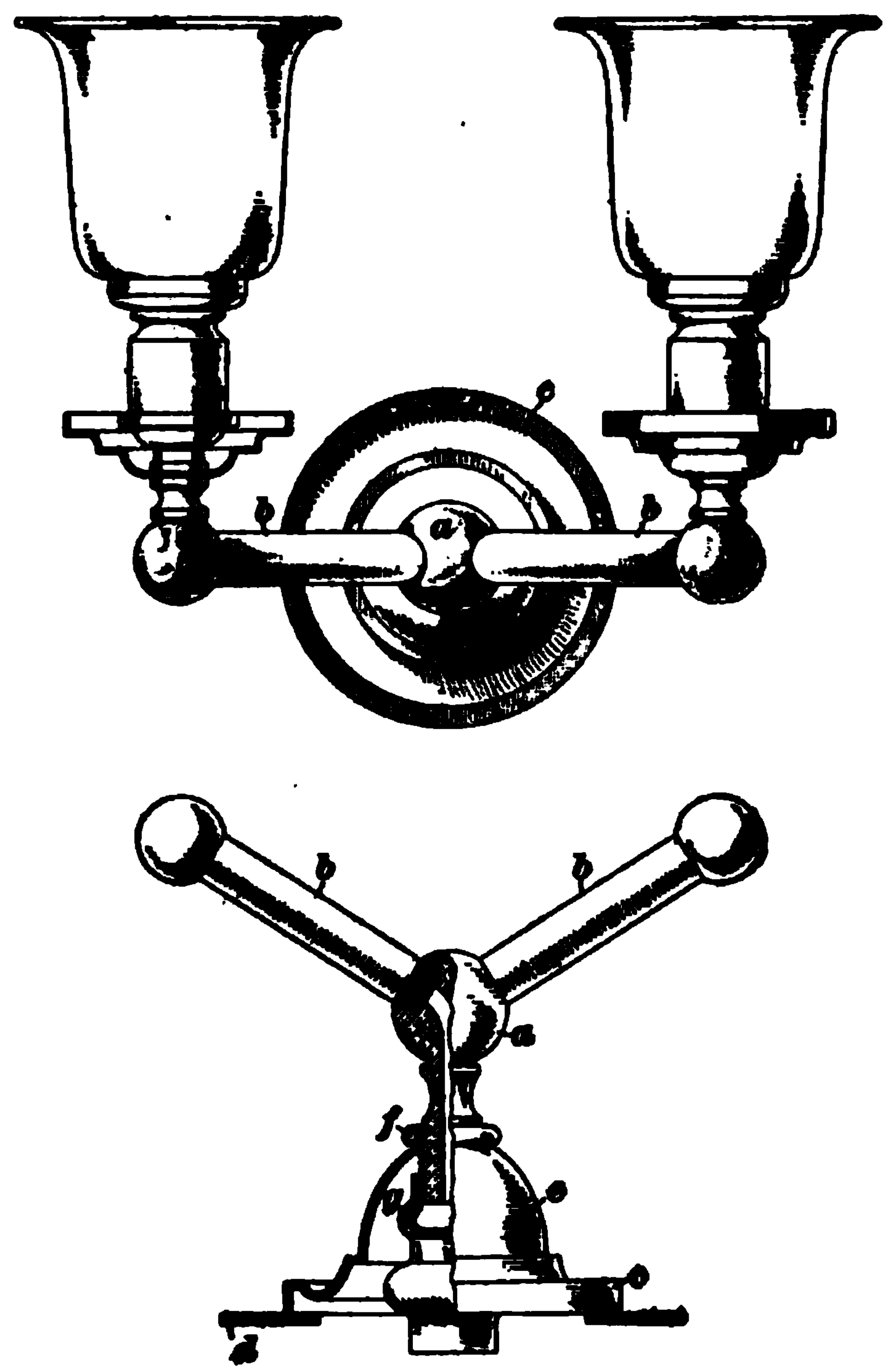


FIG. 11

11. Brackets for Two or More Electric Lights.—In conjunction with the other essential parts, the brackets for two or more electric lights are practically the same as those used for one light, and are formed by a combination of a body *a* and arms *b*, *b*, as shown in Fig. 11. In connecting brackets, when the bracket back *c* comes in contact with any metal surface, such as wall plates or other parts of the structure, great care must be taken to properly insulate the space covered by the bracket back. This is accomplished by placing a layer or ring of insulating fiber between the bracket back and the metal surface. In the construction of electric brackets, owing to the body being

brought as close to the wall as possible, a screw back *e* is used. This screw back is furnished with a circular fitting, or pin *f*, which operates along the extended threaded connection of the body with the hickey *g*. In addition to operating on the thread of the body, the screw back is also made so that it can slide over the fitting between the body and the screw back, thereby allowing freedom while the bracket is being secured to the wall and the wires are being connected.

12. One-Light Combination Brackets.—Brackets constructed for the purpose of illuminating with gas and electricity are called **combination brackets.** A combination stiff wall bracket is shown in Fig. 12, the gas tip being above and the electric lamp below the arm. Combination brackets for one light are constructed with an insulating joint *a*, a tube finisher *b*, iron pipe *c* for the gasway, tubing *d* for pipe and electric wires, body *e*, cock *f*, burner *g*, electric socket *h*, holder *i*, shade *j*, and lamp.

Fig. 12

The insulating joint shown in Fig. 13 is of the same construction as that shown in Fig. 9, with the addition of a hole drilled through the center for conducting the gas. The tube finisher, or hickey, used in the construction of combination brackets, however, is different in design from the electric-light brackets. It is made of cast iron and has four clutches, or claws, *a*, *a* on the outer edges, as shown in reaction in Fig. 13 and in elevation in Fig. 14. These

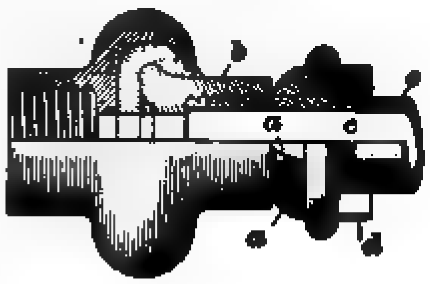


Fig. 13

Fig. 14

clutches touch the insulating joint *b*, Fig. 13, when connected. The wires carrying the current are passed between the clutches, or claws, and along the outside of the iron gasway *c*.

The combination fitting is a metal casting drilled large enough to permit the connection of the gasway and a separate space for the wires. The metal tubing *d* covering the iron pipe or gasway must be ⅜ inch larger in diameter than the outside size of the iron pipe *c*. This allowance provides a space for the passage of the electric wires to the socket. The tubing is held in position by a seating on the body.

13. Two-Light Combination Brackets.—The combining of two gas burners with two incandescent electric lamps in a bracket is called a **two-light combination bracket**, a good example of which is shown in Fig. 15. The construction is practically the same as that of the one-light combination bracket shown in Fig. 12. Brackets are

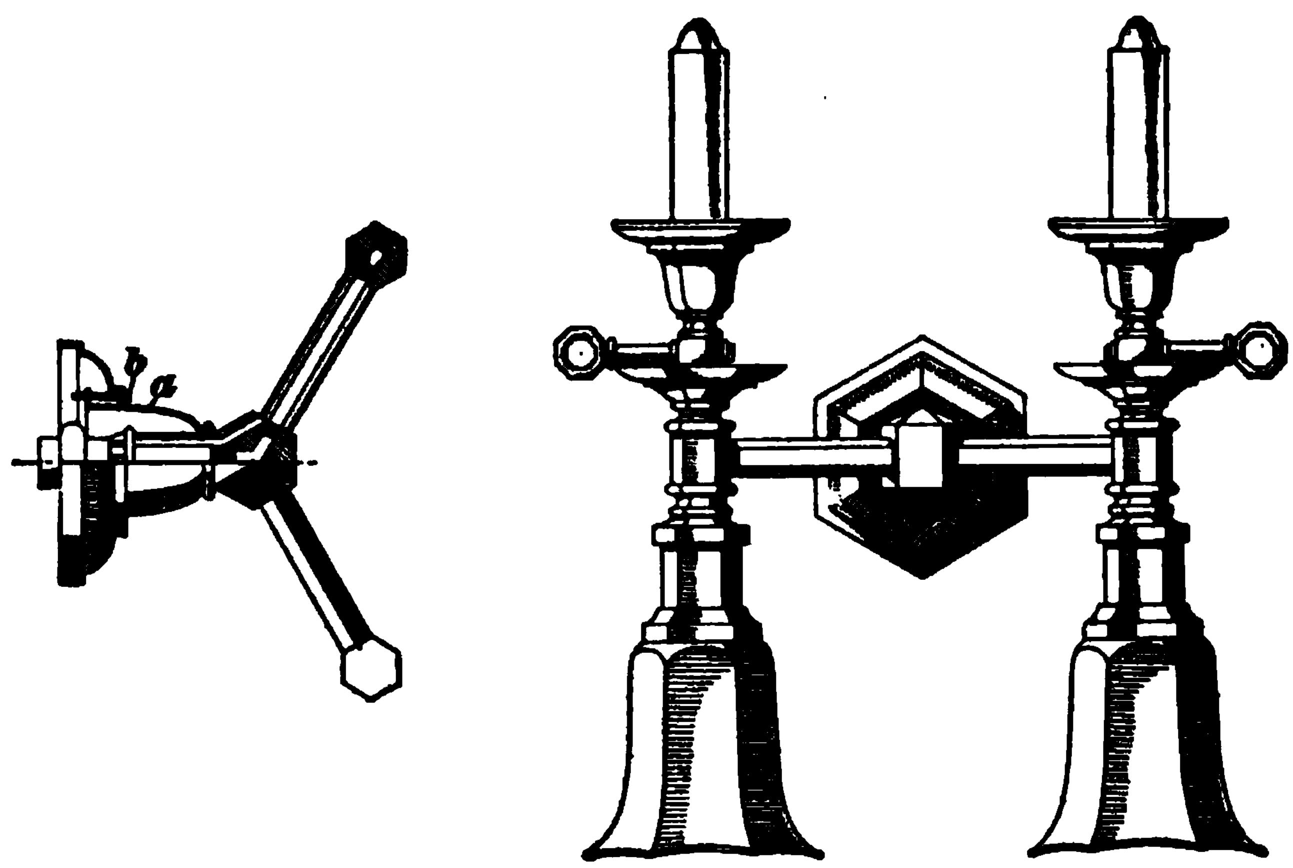
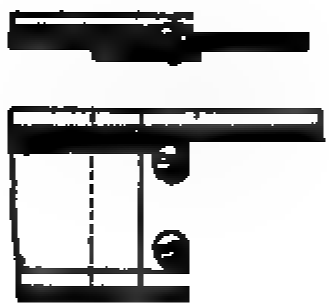


FIG. 15

constructed of various materials adapted to the purpose desired and should be placed about 5 feet 6 inches above the floor. The combination bracket shown in Fig. 15 is furnished with a telescope, or bracket back *a*, designed so that an adjustment can be made by screws *b*, as shown. This device permits the bracket to be brought as close to the wall connection as possible.

(a)



(

(c)

Fig. 16

14. Gas Column Brackets.—Brackets that are attached to columns, or pillars, by bands encircling them are known as **column brackets.** A four-light straight-gas column bracket employing four bent arms in the circle is illustrated in Fig. 16, an elevation of the fixture being shown at (*a*), a detail of the joints in the ring, or band, at (*b*), and a plan view of the fixture, showing the column in section, at (*c*). The manner in which the supply of gas may be furnished to the arms in cases where gas pipes cannot be run inside of the column is shown in Fig. 16. The gas pipe *a*, as shown at (*c*), is run on the face of the column, and supplies gas to the special fittings *b* through horizontal tubing *c*, the joints between the tubing and the fittings being made with unions as shown. The fittings are firmly secured to the column with screws, as shown at (*a*). The ring, or band, *d* is placed in position and is securely fastened there by the arms *e*, which are tightly screwed into the outlets of the fittings. The space between the under side of the ring and the column is closed by a plate *f* made in two sections and bolted to the ring, thus concealing the piping inside of the ring.

If the pipe *a* can be conveniently run inside of the column, it is advisable to do so, for this will insure a neater finish. The outlet of the gas pipe where it would come through the column can then be screwed into the back of one of the fittings *b* previously drilled and tapped to receive it.

15. Electric Column Brackets.—Fig. 17 illustrates, in elevation at (*a*) and plan view at (*b*), a **straight-electric column bracket**, the connections being shown at (*b*). Each outlet fitting of an electric column light must be provided with an insulating joint *a* and a hickey *b*, as shown. Each arm may be provided with separate wires, which are connected to the feed-wire substantially as shown at *c*. The fixture shown in Fig. 17 is also provided with cast bands and sheet-metal plates.

To prevent a ground between the fixture and the column, it is advisable to have the plate *d* at least ⅛ inch clear of the metal column all around and maintained at that distance

(b)

Fig. 17

(a)

(b)

Fig. 18

by a separate ring *e* of suitable non-conducting material, which must be securely bolted to the plate.

16. Combination Column Brackets.—Fig. 18 illustrates, in elevation at (*a*) and plan view at (*b*), a **combination column bracket.** The connections of the arms are shown at (*b*); they are practically the same as those described for Figs. 16 and 17. The arms of the fixture shown in Fig. 18 are constructed of combination arm tubing, and the fittings are provided with passages for both gas and electric wires. The entrance for gas to the arm tubing is made in the center of the fitting; that for the electric lighting, to the side of the center at the bottom. When separate outlets are used, each must be provided with an insulating joint. An insulating joint is shown located between each T on the gas tubing, as at *a*. No hickey is used, as the wires are run into each arm direct, as at *b*. This fixture is also provided with a plate *c* and an insulating disk *d* to close the lower end of the band, or ring *e*. The gas tips of this fixture are located at *f*, and the gas keys at *g*.

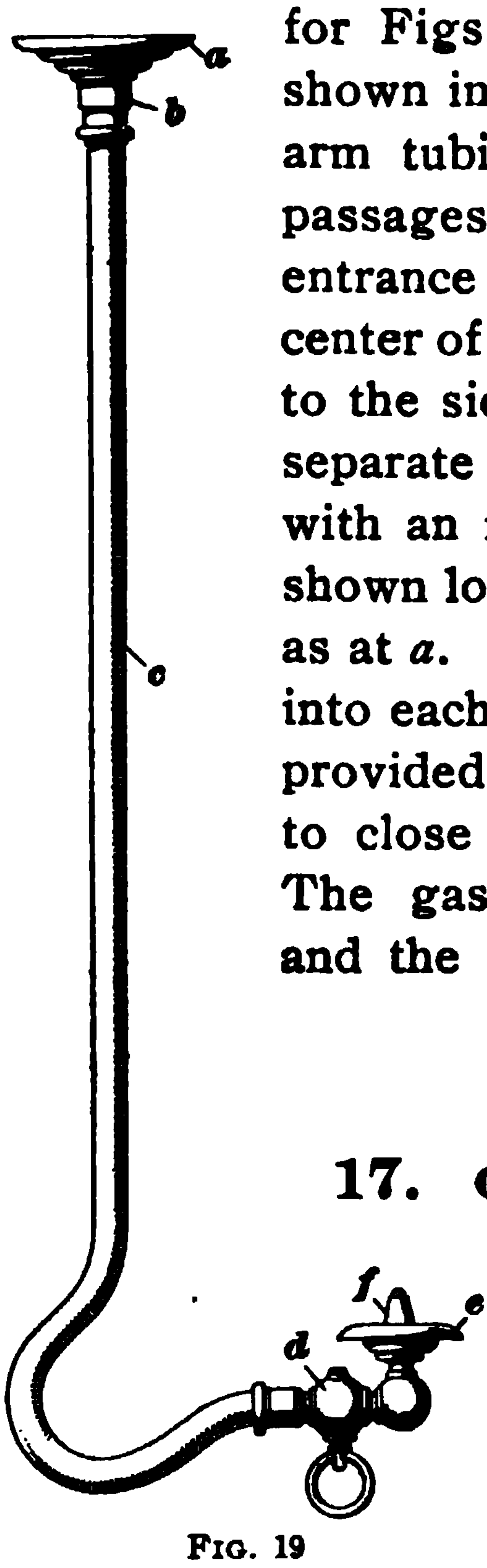


FIG. 19

PENDANTS

17. Gas Pendants.—**Pendants** belong to the old order of hanging lamps and lanterns, and are constructed for the purpose of illumination from a suspended connection.

Gas pendants, as shown in Fig. 19, are composed of a ceiling plate *a*, stiff joint *b*, tubing *c*, cock *d*, burner cap *e*, and burner *f*. The ceiling plate is a spun metal shell, and must be large enough to cover the roughness around the gas outlet at the ceiling and of sufficient depth to permit the stiff joint to be connected. The stiff joint is threaded on top to fit the gas outlet, which is generally ⅜-inch iron pipe; at the bottom, it is

threaded to receive the tubing or gasway. The cock *d* is placed on the gasway at a point convenient to reach, the distance above the floor being about 6 feet 6 inches or 6 feet 8 inches.

FIG. 20

18. Electric Pendants.—An **electric pendant** is shown in Fig. 20. Its component parts are practically the same as those used in the construction of an electric bracket similar to that illustrated in Fig. 8.

19. Combination Pendants.—**Combination pendants** similar to the one shown in Fig. 21 are of the same general construction as combination brackets, except, of course, that pendants require an extra length of tubing. In addition to the regular gas tube, or gasway, a covering tube for the passage of the electric-light wires must be provided. Care should also be taken to have the center of the gas burner not less than 4 inches away from the covering tube, as shown, so that the gas flame will not injure the finish of the tubing nor destroy the insulation of the electric-light wires.

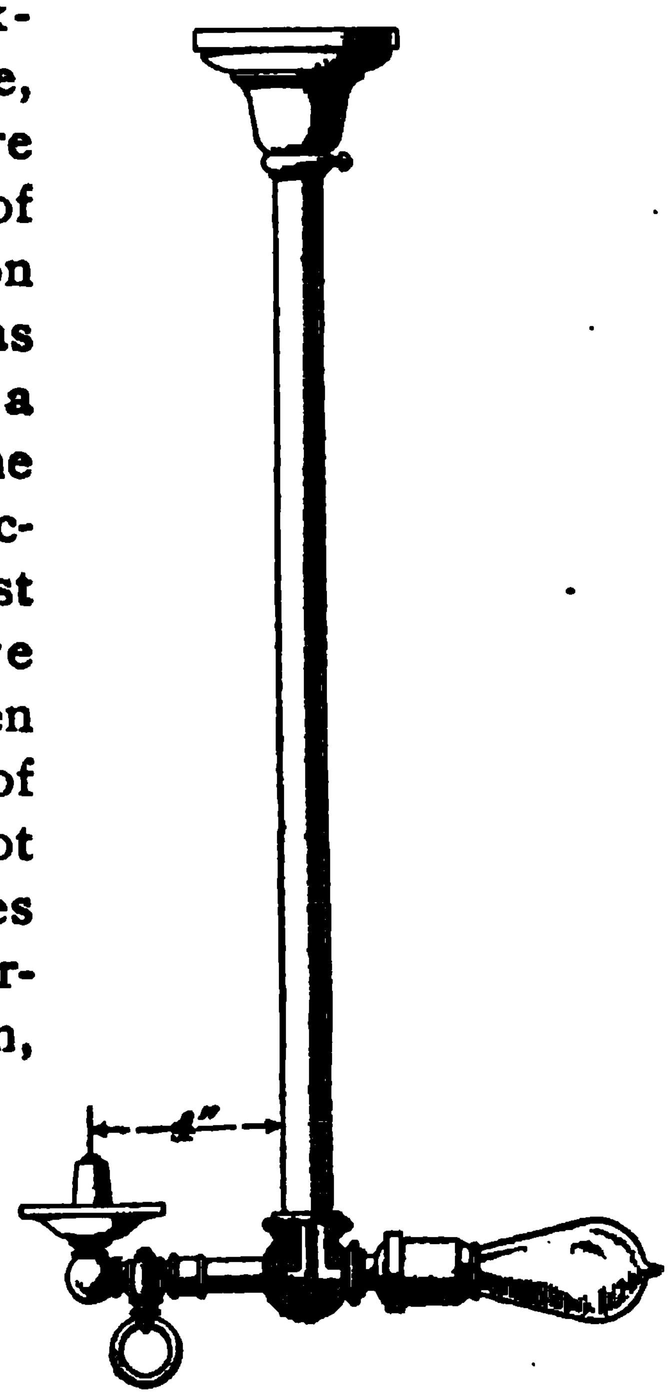


FIG. 21

20. Reflector Pendants. In Fig. 22 is shown a pendant with two or more gas burners connected to the body by short arms. A reflector suspended above the lights and

enclosing them gives to this style of pendant the name **reflector pendant.** The reflector *a* is of sheet metal, the interior of which is enameled white or is covered with pieces of mirror or art glass held in position by a metallic frame.

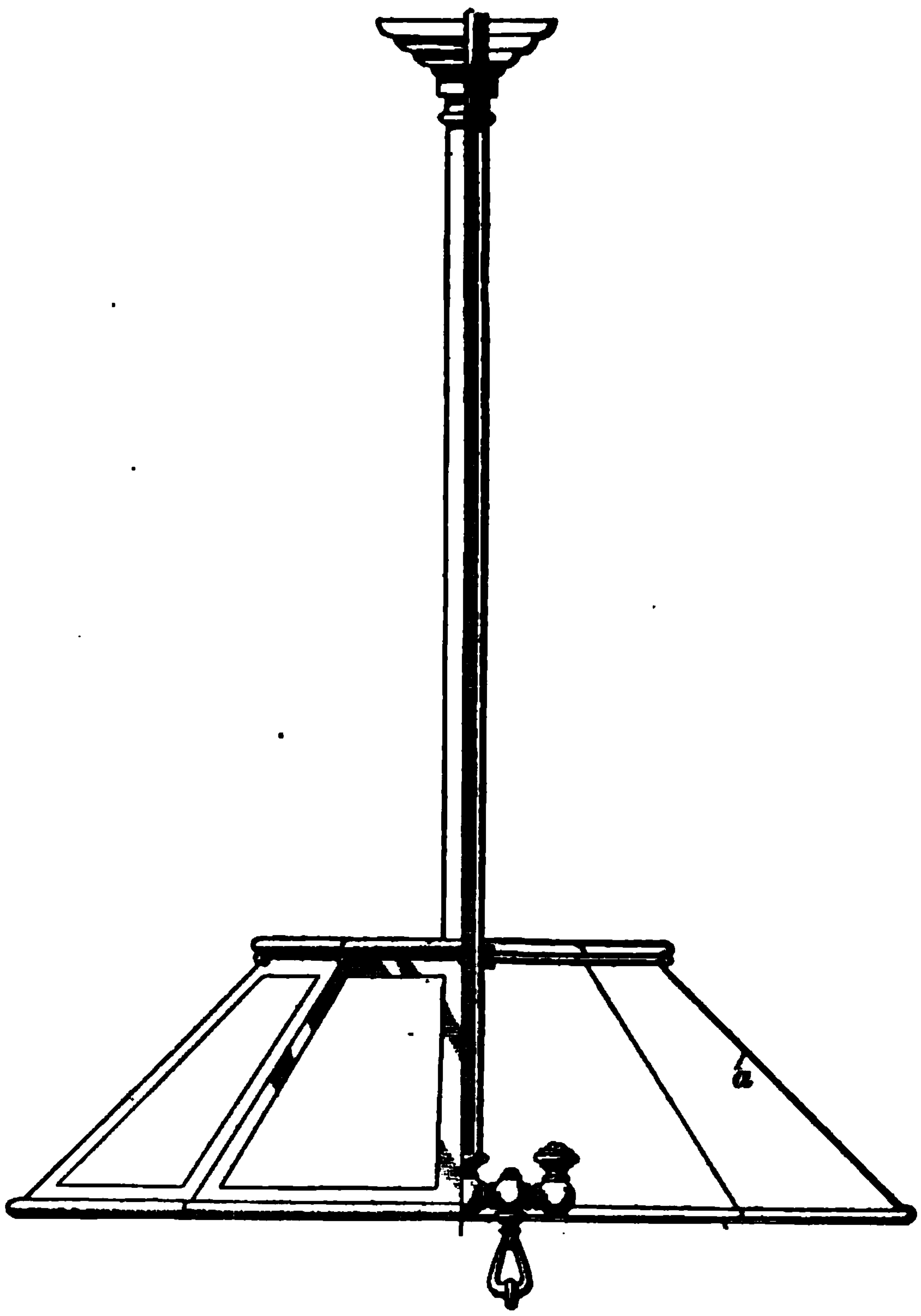


FIG. 22

21. An electric pendant having two or more lamps connected to the body by short arms and covered by a reflector is shown in Fig. 23. In electric illumination, mirrors set in a framework, enameled sheet metal, and ground or opalescent glass are used as reflectors, those made of opalescent glass being in most common use. While these reflectors answer in a way the purpose for which they are used,

they do not diffuse or distribute much more than 50 per cent. of the light. Because of the character of their composition and form, reflectors frequently have a tendency to allow too much of the light to escape in an upward direction or to the sides, while directly below they cast very little reflection in proportion to the intensity of the light.

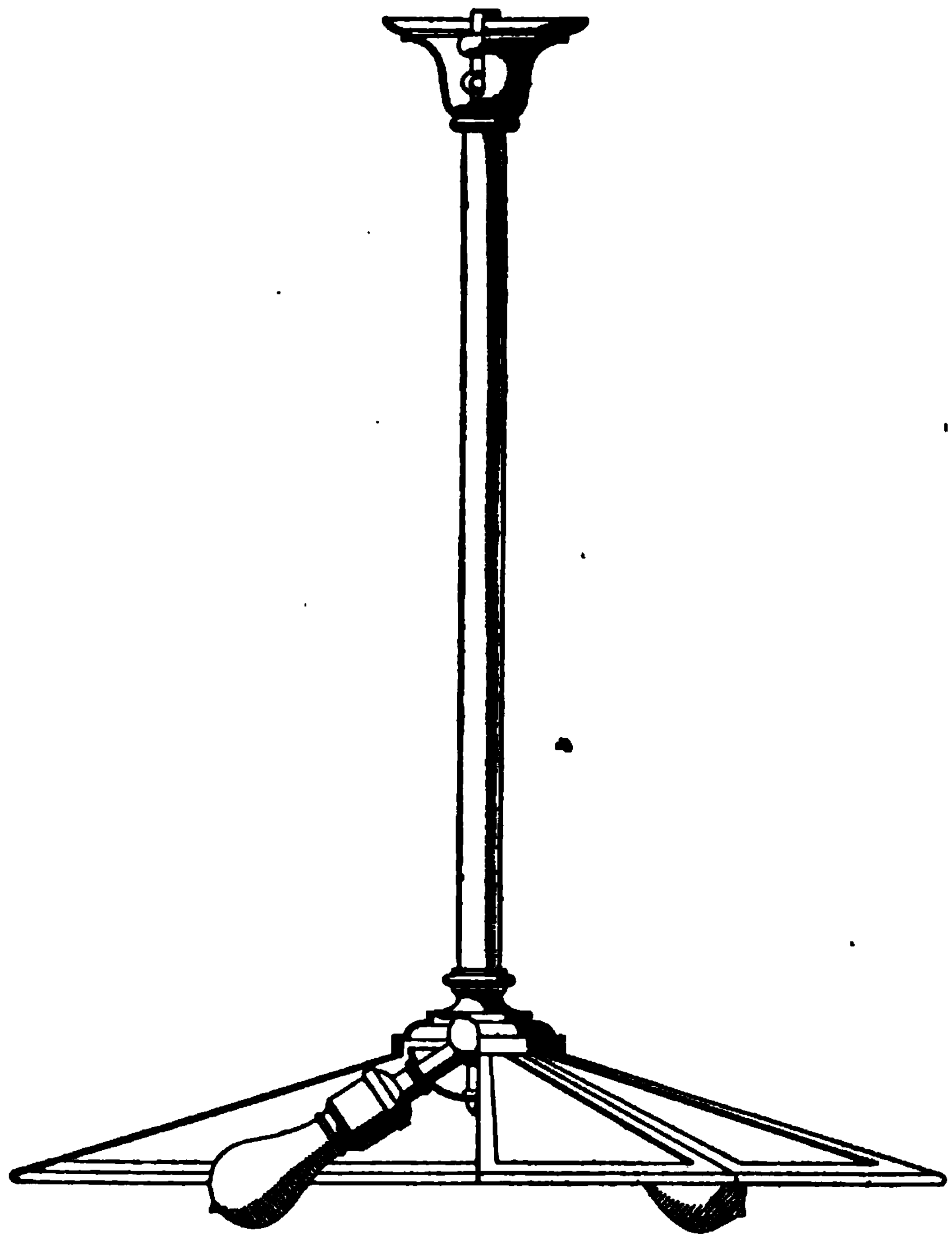


FIG. 23

22. Holophane Shades.—A proper diffusion of the light emitted by either gas burners or electric lamps can be obtained by the use of special kinds of globes, or shades, known as **Holophane.** There are many designs of this ware made to suit different conditions, but they all operate in the same general way; that is, to refract, or bend, the rays of light and thus cause a portion of the light to be projected where desired.

Holophane ware is made of pressed glass, the proper diffusion of light being obtained by a series of vertical prisms on the inner surface and a series of annular compound prisms on the outer surface. Ordinarily, holophane globes are used for throwing the light downwards, as, for example, over a dining-room table.

FIG. 24

23. Combination Reflector Pendants.—Combination reflector pendants are made in practically the same manner as those illustrated in Figs. 22 and 23, except that an electric lamp is placed on one side of the tubing and a gas burner on the other, as shown in Fig. 24; or, as shown in

Fig. 25, gas burners may be placed above the reflector, in which case the burners act as emergency lights.

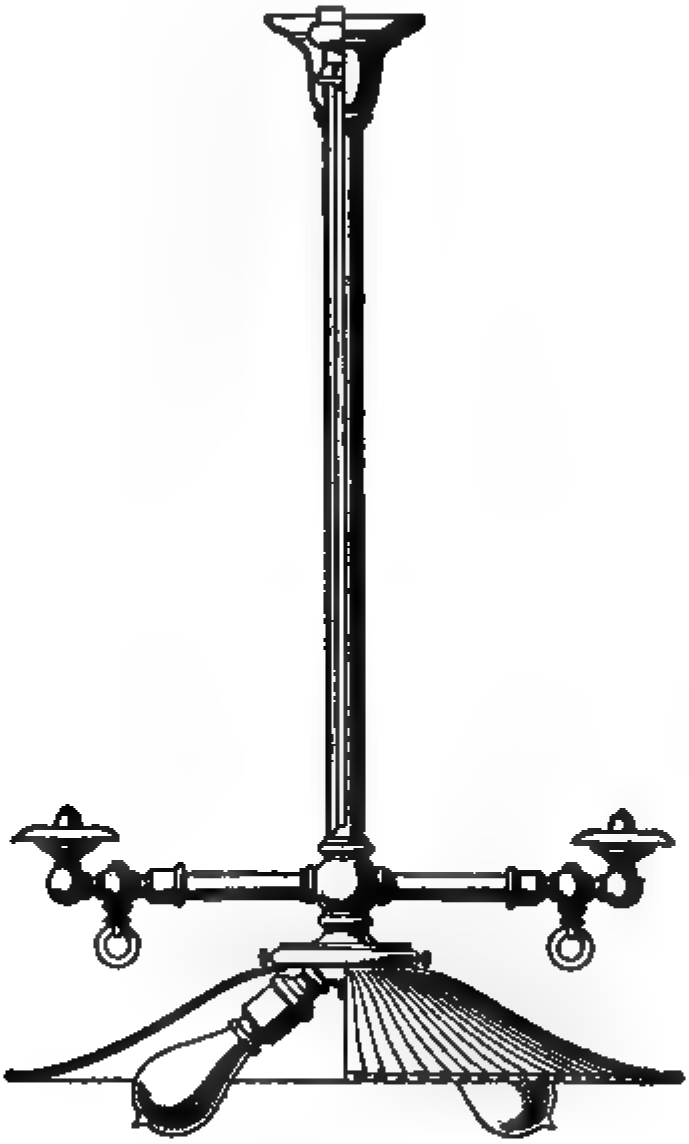


Fig. 25

LANTERNS

24. Lanterns are similar to pendants in style and construction, but the gas jets or electric lamps are entirely enclosed by a covering of glass held in position by a metallic frame. A convenient lantern is constructed with a view to providing space enough for cleaning or to make the necessary changes in the gas burners or electric lamps.

25. Gas Lanterns.—In Fig. 26 is shown a gas lantern, the construction of which embraces the same principles as a gas pendant, with the addition of several

Fig. 26

parts, as follows: The body *a*, which is turned out of bar metal, is fitted to the end of the stem and thus holds the harp *b* in position. The harp is made of brass tubing, and has a cock and burner at the bottom in the center of the glass cylinder *f*. The smoke-bell *c* is of spun metal or glass, and serves to protect the harp and fitting from the soot and heat of the flame. The hood *d* is fitted to the stem over the body, and the lantern frame *e* is held in position by metal straps, which are riveted or screwed to the hood and frame. The glass cylinder *f* is placed in the lantern frame inside of the bands *g* and straps, and is held in position by the bottom band, which is attached to the frame.

26. Electric Lanterns.—The stem of an **electric lantern** is generally constructed in the same manner as an electric pendant, but in Fig. 27 is shown an electric lantern in which a chain is used for the stem. The structural parts of this lantern are an insulating joint, hickey, screw canopy, chain fitting *a*, chain *b*, tube ring *c*, ring fitting *d*, iron stem *e*, body *f*, arm *g*, socket *h*, lamp *i*, holder *j*, and globe *k*.

The screw canopy at the ceiling is adjustable, and is fitted to the top of the stem, which, as already stated, is in the form of a chain. In making connections, the screw canopy is adjusted so as to allow a proper wire connection to be made, after which it is raised close to the ceiling, screening from view the insulating joint and hickey, and secured in position by means of a circular ring or a screwed fitting. The wire connection of Fig. 27 is made through the insulating joint and hickey, the wires passing through the center of

FIG. 27

the fitting at the end of the canopy, a hole being bored through this fitting to allow for their passage. The use of a chain stem makes it necessary for the wires to be exposed from the fitting to the tube ring, because, if they were passed through the links of the chain, there would be danger of the wires becoming bared, thereby risking a contact with the metal parts of the chain. The wires are passed through a hole in the tube ring, then through the iron stem and body, and are finally connected to the socket, thus completing the connection. The holder *j* is a spun shell and should not be less than No. 16 gauge in thickness. It is provided with four setscrews to hold the globe in position.

27. Combination Lanterns. Combination electric and gas lanterns must be designed with a view toward allowing a certain amount of air to pass through them. If they were made air-tight, the heat of the gas flame would burn the insulation of the electric wires, besides depositing soot on the inside of the lantern. Combination lanterns are constructed in practically the same way as combination pendants.

FIG. 28

In Fig. 28 is shown a box-shaped lantern, the top, or hood, of which is provided with openings at *a* to permit heat to escape from the interior. The lantern frame and hood are usually made of cast metal, but if sheet metal is employed, No. 16 gauge or thicker will be found very satisfactory. All joints should be brazed or riveted.

In constructing a box lantern, means should be provided for cleaning the interior and for changing the gas burners and lamps. This may be accomplished by having one of the sides connected to the frame with hinges, so as to allow the leaf to swing outwards; when closed, it is secured by a small wire drop bolt that fits into a socket on the frame. The gas burner must be placed at a distance not less than 2 inches from the center of the stem and away from the electric lamp, so as to keep the direct heat of the gas flame safely away from the electric connections.

28. Bracket Lanterns.—Lanterns combining a bracket and a lantern in construction are called **bracket lanterns,** and are used for street and open-air illumination. A gas bracket lantern is shown in Fig. 29. This fixture is very much like the one shown in Fig. 3, except that a lantern is placed on the bracket. The parts of bracket lanterns are always built on a larger scale, as they are exposed to more danger than indoor, or house, brackets.

In Fig. 30 is shown an electric bracket lantern that is made practically the same as the fixture illustrated in Fig. 7 with the addition of a lantern.

Fig. 29

In cases where the bracket lantern is fastened to a stone wall, a casting, or tripod, shown in Fig. 30 (*b*), is used. The tripod is secured to the stonework by expansion bolts, as shown at *a*, a sliding or adjustable back *b* being used to cover the tripod connection.

29. Combination Bracket Lantern.—A combination bracket lantern is shown in Fig. 31, and is of a similar construction to the combination bracket shown in Fig. 12, with the addition of the lantern. This fixture is furnished with a telescope back—a bracket back by which, through the

adjustment of screws *a*, it is screwed up tightly between the fitting *b* and the wall.

30. Hanging Bracket Lantern.—When the position of a bracket lantern is reversed, it is called a **hanging**

FIG. 30

FIG. 31

bracket lantern. By reversing Fig. 31, this effect can be obtained; the ventilating hood, however, would then be placed over the top of the globe.

CHANDELIERS

31. Introduction.—The arrangement of a number of lights in a circular form on a suspended framework, for the purpose of giving additional illumination with perfect security, led to the construction of the **chandelier.** In the middle ages, the lights were placed in one plane; that is, although there were several rings of lights on a chandelier, they were placed on one level, no light occupying a higher or a lower position than any other in its respective circle. The

principle of illumination in a circular form was still adhered to in the Renaissance, but the lights were placed on arms, or holders, separately connected to the body of the chandelier. In this era, there also appeared chandeliers having an alternation of lights in different rings; this style of chandelier is still in use.

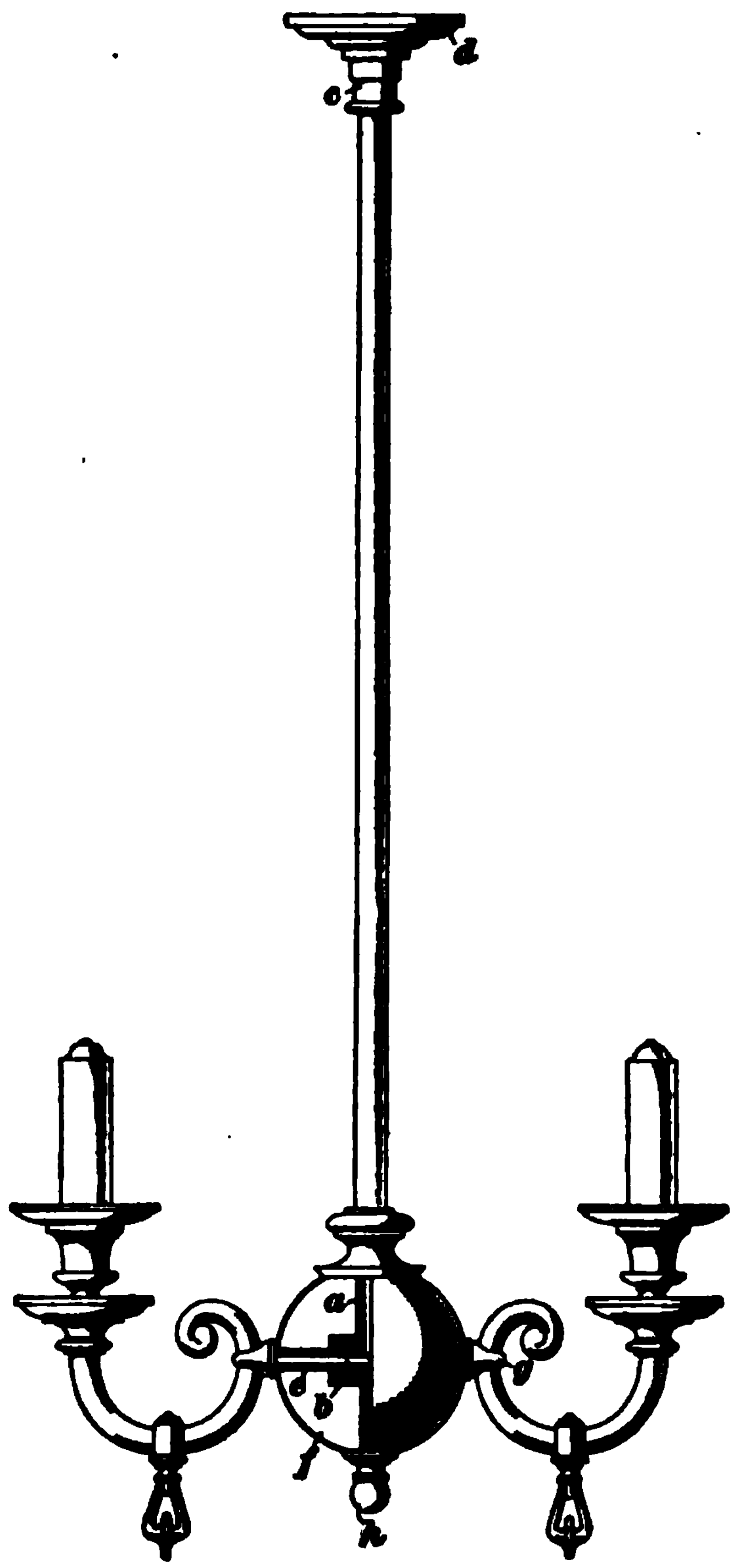


FIG. 32

In the middle ages and the Renaissance, the use of candles and oil as illuminating factors provided but a small field for bringing the chandelier to an advanced degree of efficiency, although the artistic sense of our forefathers was fully gratified, as is aptly illustrated in the beautiful ornamentation of their works that are still preserved. The use of gas and electricity as agencies of illumination has brought the chandelier of the present day to a high state of perfection. And the facility with which these products can be handled has done much toward making the chandelier a very popular method of illumination.

32. Construction. Chandeliers are made in various styles and sizes, and can be obtained for straight-gas, straight-electric, or combination work. Figs. 32, 33, and 34 show chandeliers intended for the general illumination of rooms in dwelling houses. For this purpose, they are usually made with from two to six arms; but for meeting halls,

churches, theaters, etc., where a great volume of light is required, they are made quite large and are equipped with more arms or jets. When the agency of illumination is gas, a chandelier may be constructed with a large variety of clusters of arms, numbering thirty or forty lights, or even more. All parts of chandeliers as well as parts of other fixtures must be constructed according to the size and weight of the fixture; the greater its proportions the stronger must be its construction.

33. Gas Chandeliers.—In Fig. 32 is shown a **straight-gas chandelier** that has only two arms, but six, or even more, may be embodied in this construction. This fixture is composed of an iron gas tube *a*; the lower end of the tube is screwed into a hollow gas body *b*, and the upper end is secured to the gas pipe at the ceiling by means of a brass coupling *c*. A spun shell *d* conceals the gas pipe, or gas outlet, at the ceiling. The gas body is provided with nipples *e* to which the arms are connected, and when a great variety or many clusters of arms are required on a chandelier, a separate body is attached to the stem for each section, or cluster. The body is covered with a spun shell *f* having as many holes as there will be arms. When the arms are connected to the body, the fitting *g* on the arms must be brought close to the body shell. A pendant knob *h* screwed to a wire connected to the bottom of the gas body and running through the shell serves to hold the shell *f* in position. The other parts of the fixture are similar to those described for other gas fixtures.

34. Electric Chandeliers.—The **electric chandelier** shown in Fig. 33 is constructed on the same principles as an electric pendant, with the addition of the body *a*, to which the arms are connected, a spun shell, and a pendant knob. The body used in electric chandeliers is made of cast iron or brass, and is provided with a tapped hole on the top and one on the bottom to connect with the stem and the wire for the pendant knob. The sides are furnished with tapped holes, into which the arms are inserted and secured by setscrews.

The arms on an electric chandelier may be curved upwards or downwards, or they may be at right angles to the stem. As incandescent lamps are employed for illumination, there can be no possible danger to the fittings from heat and smoke, as would be the result if gas burners were placed on chandeliers in any position other than vertical.

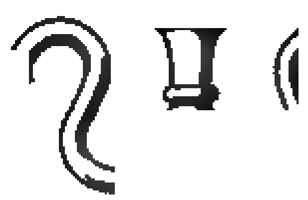


Fig. 33

A chandelier with the lights encircling the stem on one or several metal bands of varying circumferences, is called a *corona fixture*. The connection to each electric arm holding the bands in position must be covered with a spun shell, which, in addition to hiding the connections of the arms, adds to the decorative effect of the fixture. These spun shells are made in various sizes and shapes to suit the number of arms to be screened at their connections. The bands employed are of varying sizes, to facilitate illuminating in concentric circles; that is, a small band is placed within the circumference of a larger one, thereby reducing the size of the shadow cast by the center lights. When properly designed this makes an attractive fixture.

35. Combination Chandeliers.—Chandeliers in combination present equally as great an opportunity for the arrangement of lights as the straight-gas or straight-electric fixtures. The fixture shown in Fig. 34 could be furnished with separate gas arms outside of the fixture, and in place of the metal shell *a* with the pendant knob *b*, a ground-glass globe might be substituted, illuminating the globe with electric lamps. This arrangement would be very suitable for a hallway or corridor. This type of fixture could also be provided with a combination of lights on the outside of the fixture, or a corona fixture could be constructed with the combination arrangement of lights. In fact, there are many combination arrangements possible, with all styles of fixtures, which are too numerous to be described here.

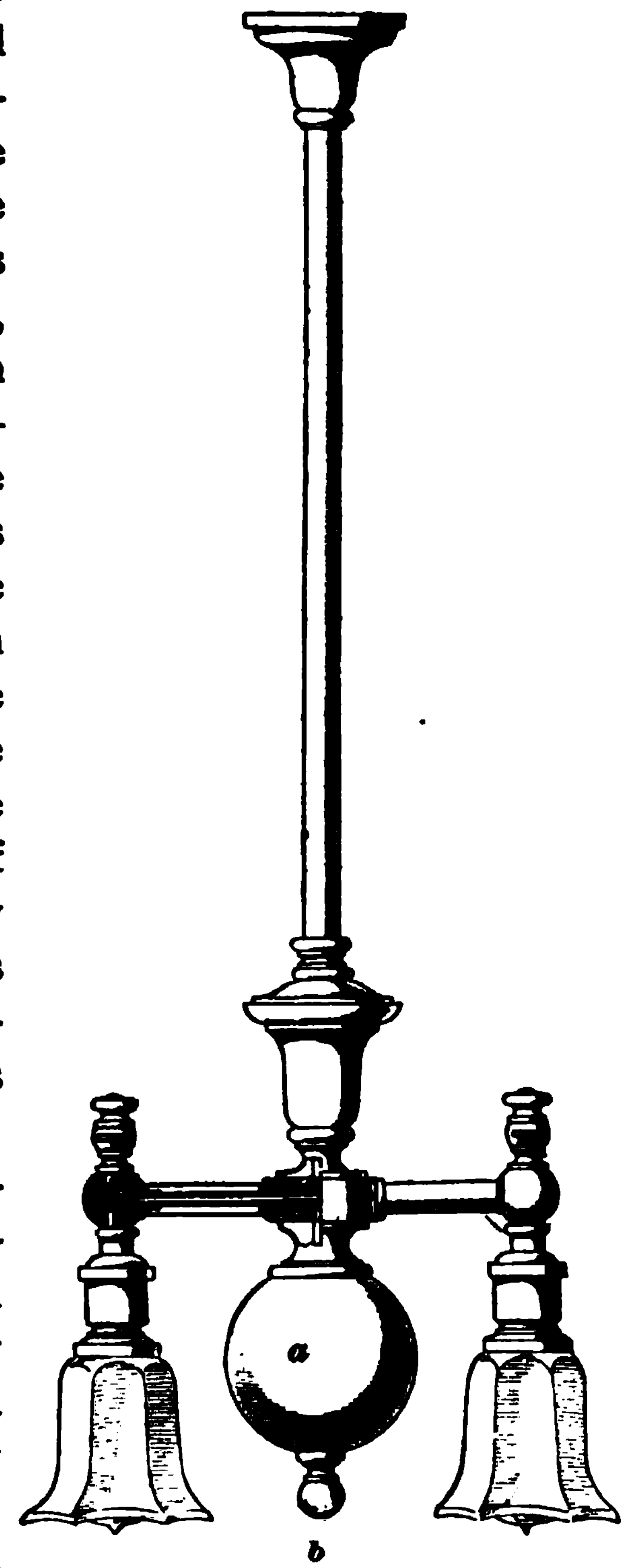


FIG. 34

Taken as a whole, chandeliers afford many opportunities to illuminate from almost all points in the body of the fixture. The arms on a chandelier are at times very plain, as in a cheap fixture, while cast arms highly ornamented, plated, burnished, or oxidized are used on costly fixtures. C- and S-shaped arms when used on chandeliers add to the decorative effect. Chandeliers can also be provided with cast ornaments along the stem.

36. Arrangement of Lights.—Lights may be arranged in tiers or circles on an electric chandelier or other fixture without any consideration of position; but when the fixture is of the combination type, the gas arms must always be placed on the upper tier. This fact should always be borne in mind in the practical designing of fixtures, for electric lamps, fittings, and connections on any style of combination fixture must be protected from the heat of the gas flame by locating gas points of illumination at least 4 inches from any surrounding metal, etc.

37. Space for Wires.—With the introduction of electricity as an illuminant, the wiring of chandeliers was often attended with disastrous results, owing to electric wires being stripped of their insulation while being passed through the shell and through holes provided for them in the various sections. Experience has taught that the wires should be placed inside of the stem tubing and that the shell must be of a size large enough to permit a free passage (about $\frac{3}{8}$ inch diameter greater than gas pipe) of the wires from the canopy to connections at the body. In connecting the wires to the sockets, the spun shell must be removed and this may be accomplished by taking off or unscrewing the pendant knob. After the connection has been made, the spun shell and the pendant knob are replaced.

38. Chandelier Details.—The body fitting commonly used in the construction of an electric chandelier is shown in Fig. 35 (*a*). The stem is screwed into the tapped opening *a*, and the arms into the tapped openings *b*, a setscrew being used in the under side to prevent the arms from twisting after having been screwed up and properly alined. The lower part of the fitting is open, a bridge *c* being cast across to support the rod attached to the pendant knob. This rod is screwed into the tapped opening *d*. Space is allowed for the wires inside of the fitting and around and under the bridge.

Fig. 35 (*b*) shows how the body fitting for a combination chandelier may be made. The tapped opening *a* is screwed

to the gas tube, and the space *b* is filled with gas. The gas arms are screwed to the tapped outlets from *b*, as at *c*. The space *d*, which is open through the body, is to receive the

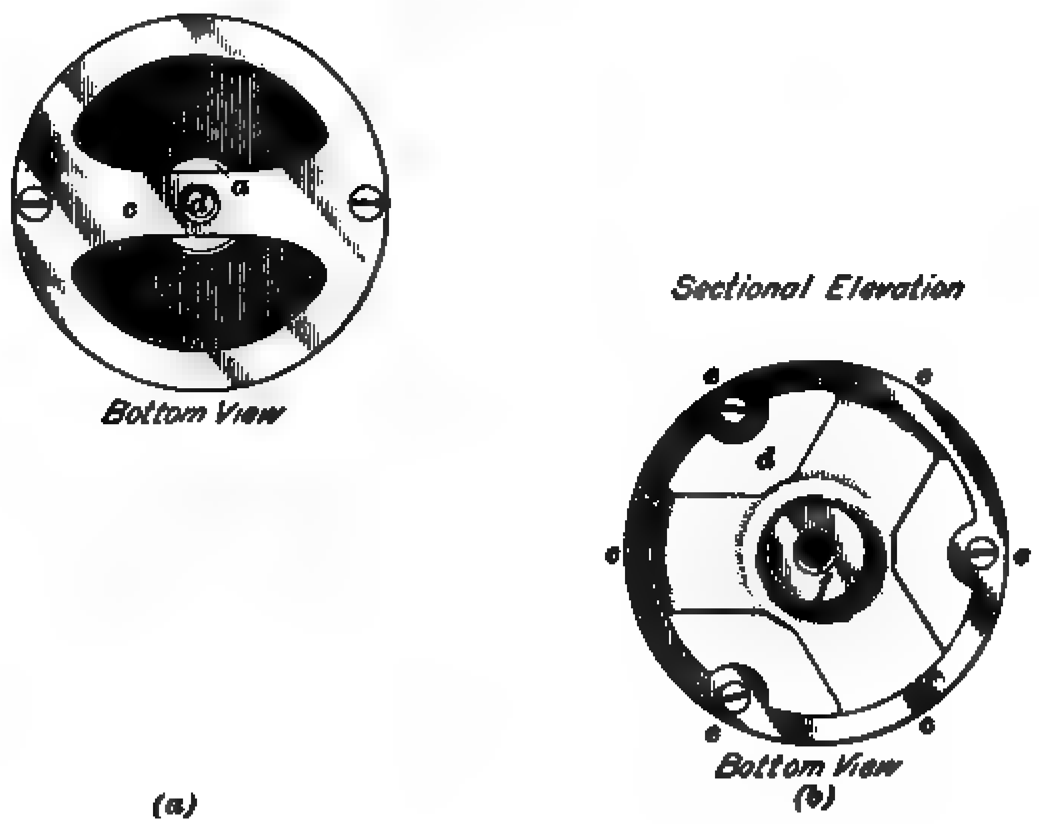


FIG. 35

wires, the tapped outlets for the electric arms being located at *e*, with setscrews under them, as shown. The rod for the pendant knob is screwed into the tapped opening *f*. The diameter of the body fitting and the number of gas and

electric tappings depend on the number of arms to be used on the chandelier.

39. An illustration of the parts used in the construction of the spun shell of the fixture shown in Fig. 34 is given in Fig. 36. The stem tubing rests on the spun neck *a*, which is furnished with a seating that fits the stem tubing with a snug joint. The part *a* rests on the section *b*, *b* rests on *c*, and *c*

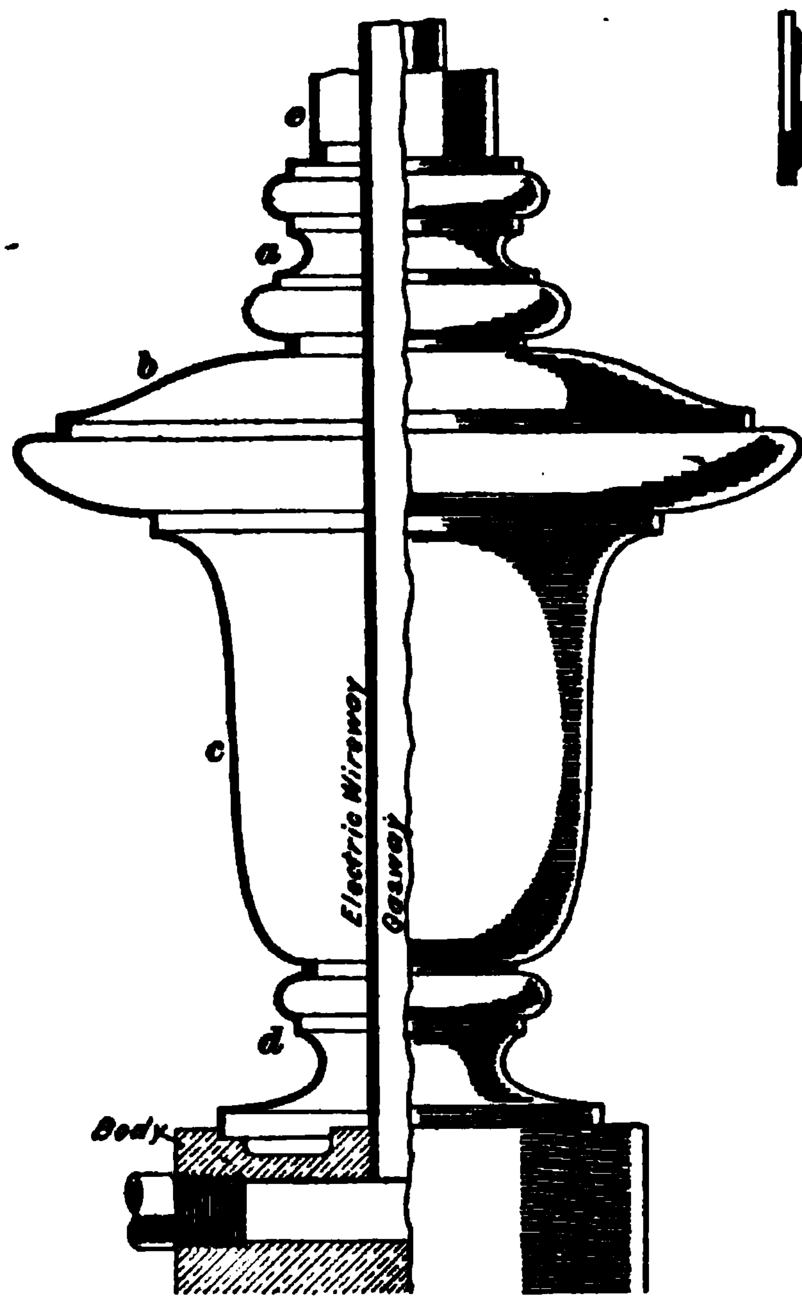


FIG. 36

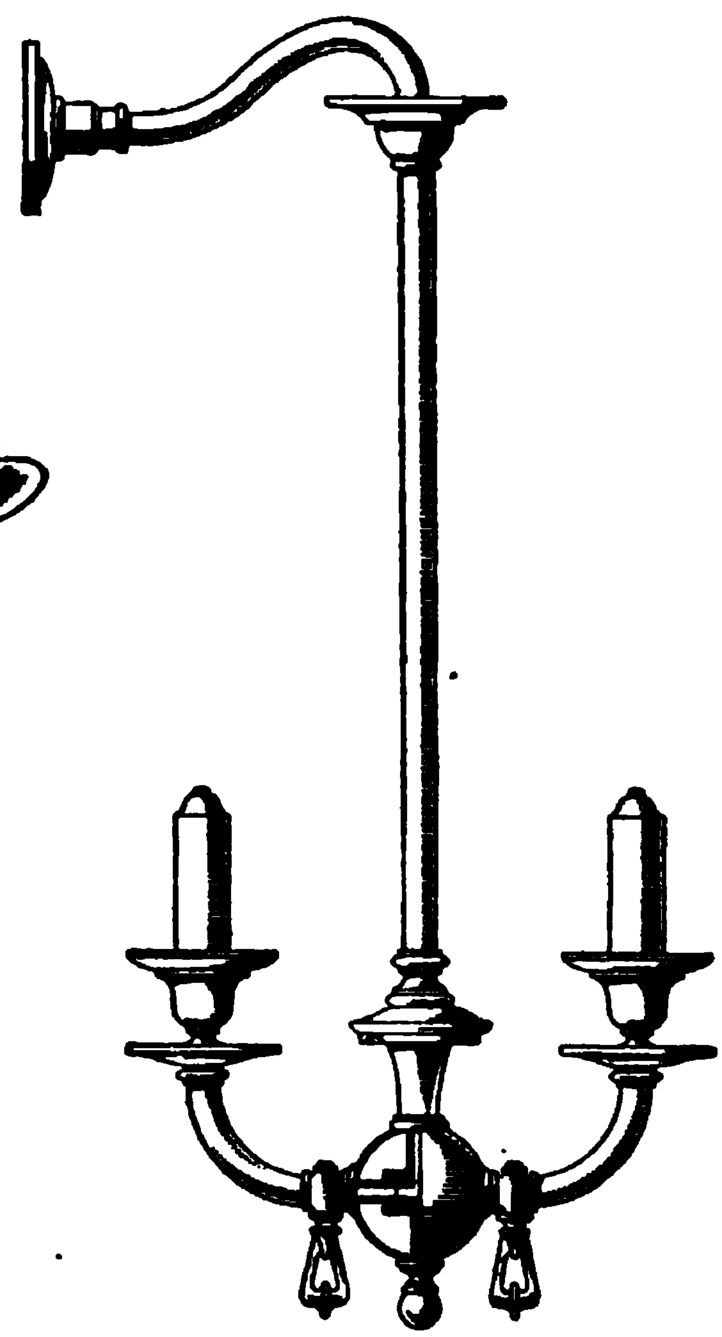


FIG. 37

on *d*, the bottom section *d* resting on the body. All the parts above the body, that is, the shell and stem tubing, are held rigidly in position by the hickey at the upper end of the tubing, which is screwed down on the top of the stem tubing *e*.

40. Toilet Fixtures.—Toilet fixtures or bracket chandeliers are constructed the same as chandeliers, but on a smaller scale. They are placed in front of mirrors, bureaus, and dressers, in bedrooms and dressing rooms, and are

connected to the wall by a bracket arm. The perpendicular drop of toilet fixtures is generally 28 inches from the wall outlet to the bottom of the fixture.

The distinguishing feature of the toilet chandeliers is the bracket used for suspending the fixture. Several illustrations of toilet fixtures are shown here, in which the construc-

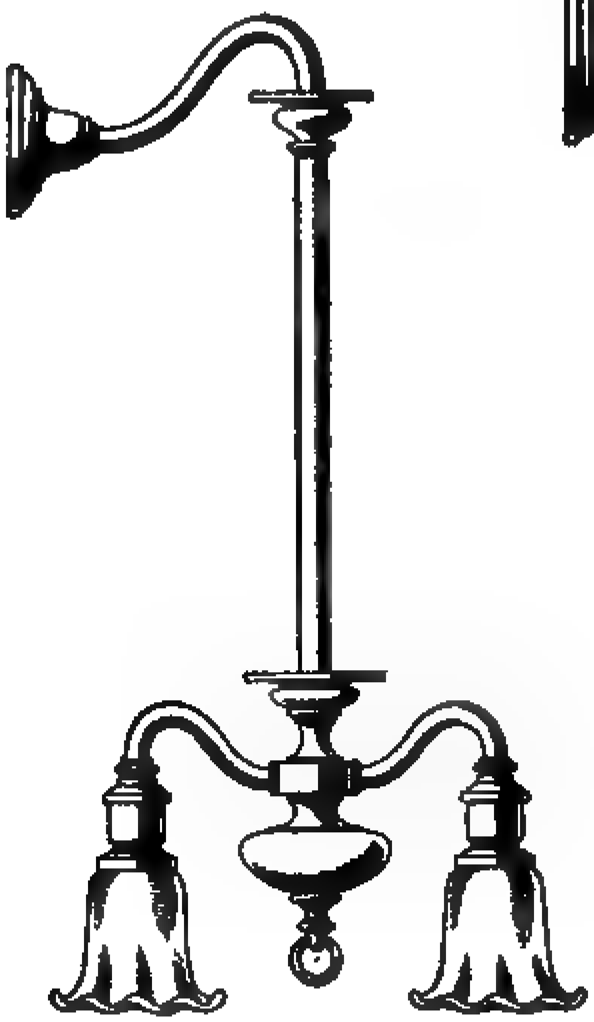


FIG. 38

FIG. 39

tion is practically the same as the chandeliers previously represented. Thus, in Fig. 37 is shown a gas toilet fixture similar to the chandelier shown in Fig. 32; Fig. 38 represents a straight-electric toilet fixture like the chandelier shown in Fig. 33; and Fig. 39 is a combination toilet fixture similar to the one shown in Fig. 34.

DINING-ROOM AND LIBRARY FIXTURES

41. The fixtures for dining rooms and libraries are designed and constructed according to the same general principles that govern chandeliers, but their light is concentrated

Fig. 40

on the dining-room or library table. For this reason these fixtures are usually furnished with a glass dome, or shade, which easily distinguishes them from the chandelier.

Fig. 40 illustrates a gas dining-room fixture of five lights. This fixture is provided with four lights on the outside of the dome, shown at *a*, and one in the center, as at *b*. The outside lights are used for illuminating all parts of the room outside of the area occupied by the dining-room table, while the center light is used chiefly to illuminate the table.

This fixture consists of a stem fitted with a body, as at *c*, four rods *d* of flat tubing, and two bands *e* and *f*. The gas is conveyed to the arms through only three of the tubes *d*, the fourth being a dummy or movable rod attached by setscrews at the top and bottom. This arrangement permits the rod to be moved to one side, thereby affording an opportunity to change the dome, which can only be taken out of the fixture through the space thus provided. The top band *f*, which is made of cast brass, is placed inside of the rods, and is held in position by four setscrews inserted through the rods from the outside. The bottom band *e* is on the outside of the fixture, and is held in position by the connections of the arms, being furnished on

FIG. 41

the inner side with a spun shell *g* on which the glass dome *h* rests. Cast fittings brazed at the connection of the band and the rods serve to hold the connection of the outside arms rigid. The outside arms are frequently made of flat tubing, with fittings brazed on the ends. The flat raised nailheads shown on the bands and end fittings are not necessary, but are simply attached as ornaments.

42. In Fig. 41 is shown an electric chain-stem fixture with an art-glass shade and a silken fringe. Art-glass shades are constructed in sections, which are held in position by a metallic frame. The silken fringe is sewed to a sheet-metal band, which is connected to the shade by setscrews. The cluster of lights on the body *a* is held in position by an iron pipe connected to the diamond loop *b*. This iron pipe is furnished with a fitting at the end, to which is connected the rod *c* for supporting a disk *d*. This disk is usually made of ground or opalescent glass, and is used to moderate the intensity of the light, making the illumination soft and agreeable to the eyes.

43. Combination Dining-Room Fixtures.—A combination fixture for dining rooms is illustrated in Fig. 42, and consists of a split canopy *a*, silk stem *b*, ring fitting *c*, spun shell *d*, cast band *e*, gas arms, electric-lighting arms, combination body *f*, lamps, and a conical art-glass shade *g* with cast band *h* and silk fringe *i*.

The split canopy is a spun shell divided into two equal sections, which are joined together by two metal straps when the fixture is installed. These straps are soldered to one section of the spun shell, one strap on each side and inside of the canopy at the line of bisection. The free end of each strap is provided with screw holes, to receive the screws inserted through the other section of the canopy. The silk stem is made by covering brass tubing with woven close-fitting silk. This silk covering is attached to two wooden knobs, also covered with silk, one being placed on the stem directly under the canopy and the other on the stem about 5 inches above the ring. The tube between the bottom

knob and the ring is screened by a silken tassel, as shown, and the ring is connected to the stem by a fitting, through one side of which the gas flows, while the electric wires enter through the other, the ring being divided accordingly. A similar fitting connects the fixture to the ring.

From the fitting at the bottom of the ring, an iron pipe with a gas body is connected, to act as a gasway for the arms. The body on which the cluster of electric lamps is arranged is held in position by a pendant knob, the stem, or rod of which is screwed into the bottom of the gas body. The fringe shown in Fig. 42 is called *knotted fringe*, and is also made of silk, being sewed to the cast band of the shade.

The construction of dining-room and library fixtures is practically the same, as is also the principle of illumination. Each serves to light up a table, and, when necessary, lights are provided for the space beyond the area of the table.

FIG. 42

44. Various Designs.—In order to show the diversity of the designs of dining-room and library fixtures, some

arrangements of lights differing from those just illustrated and described will be given. For instance, the design shown in Fig. 40 could be made up of only two lights on the outside and one on the inside. In this case, the supply of gas would necessarily have to pass through only two of the flat tubes *d*.

Owing to the stem in Fig. 41 being made of links, lights could not very well be added to it; but at the fitting at the end of the diamond loop, from two to six lights could be placed, or, considering the size of the fitting and the connections, practically as many lights as could be added thereto. Too many lights should not be around a central point on any fixture, however, and a reasonable space should always be allowed between the arms, or sockets. The fixture shown in Fig. 41 might also be provided with a body under the canopy at the ceiling to which four or five lamps could be attached, thus giving a better general illumination.

45. While the usefulness of the fixture must not be overlooked, it should be remembered that the public demands and expects an artistic treatment that will help in decorating and furnishing the room.

Being a combination fixture, many additions and alterations may be made to the fixture shown in Fig. 42. It may be provided with a body and lamps, under the canopy, the same as an electric fixture. Clusters of lights can also be placed along the stem about 1 foot from the ceiling. This arrangement will bring into use a combination body, which can be covered with a spun shell. When a silk-stem fixture is furnished with a cluster of lights on the stem, the silk covering must be in two parts, and each part provided with its own complement of knobs.

The emergency lights in Fig. 42 may be placed around the bottom band *h* if desired. When constructed in this manner, a connection must be made to the gas body at the end of the stem by running metal tubes along the ribs of the shade and placing them either on the outside or the inside of the shade. The lighting of electric lamps on fixtures that are beyond

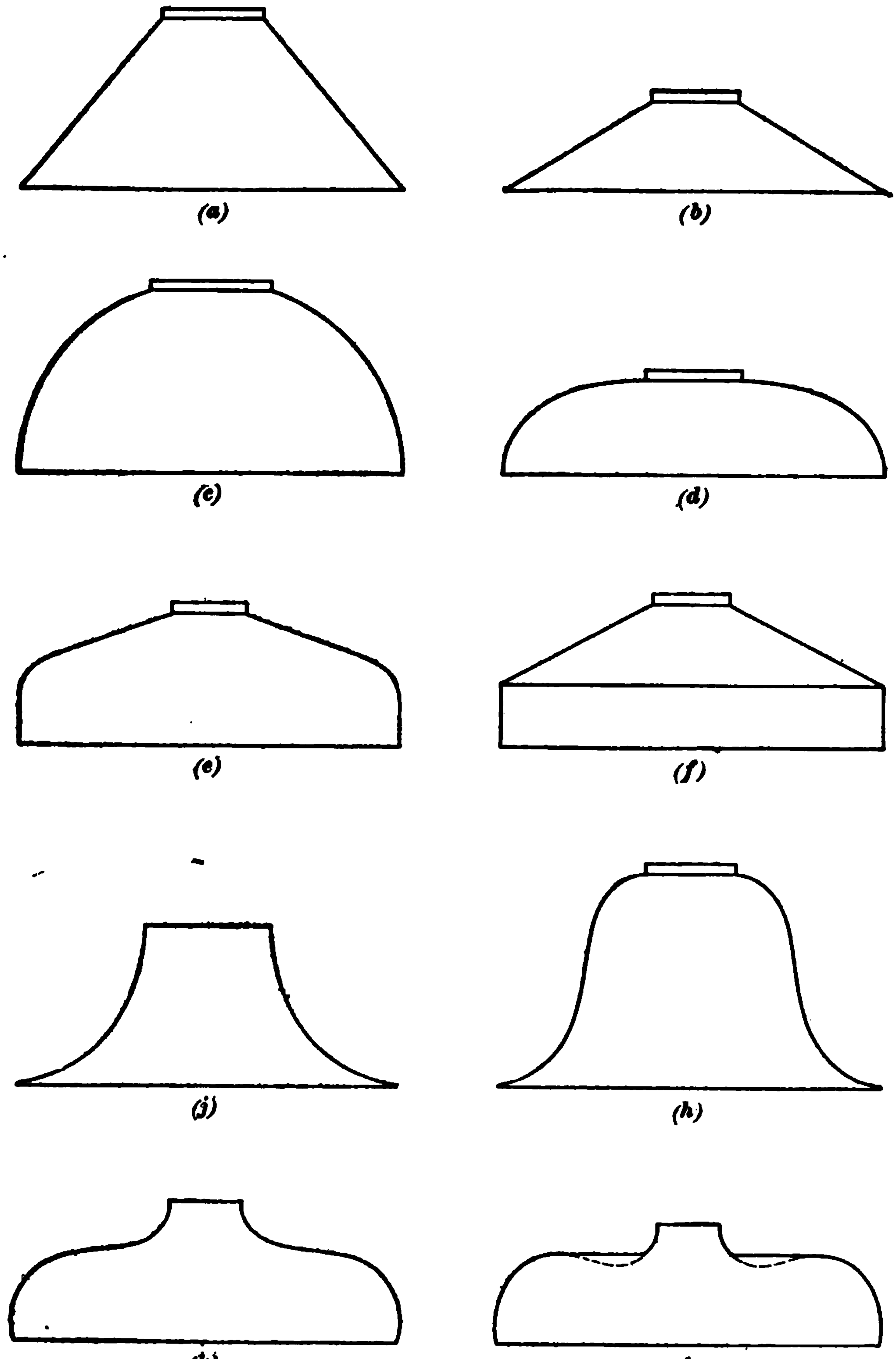


FIG. 43

reach may be controlled by a push-button switch suspended from the pendant knob of the fixture.

46. Domes and Shades.—The glass or mica domes and shades used for dining-room and library fixtures may be of almost any shape. They are generally constructed, however, so that they form geometrical figures in plan. A few designs in common use are shown in side elevation in Fig. 43. Transparent glass is rarely used for shades, translucent,

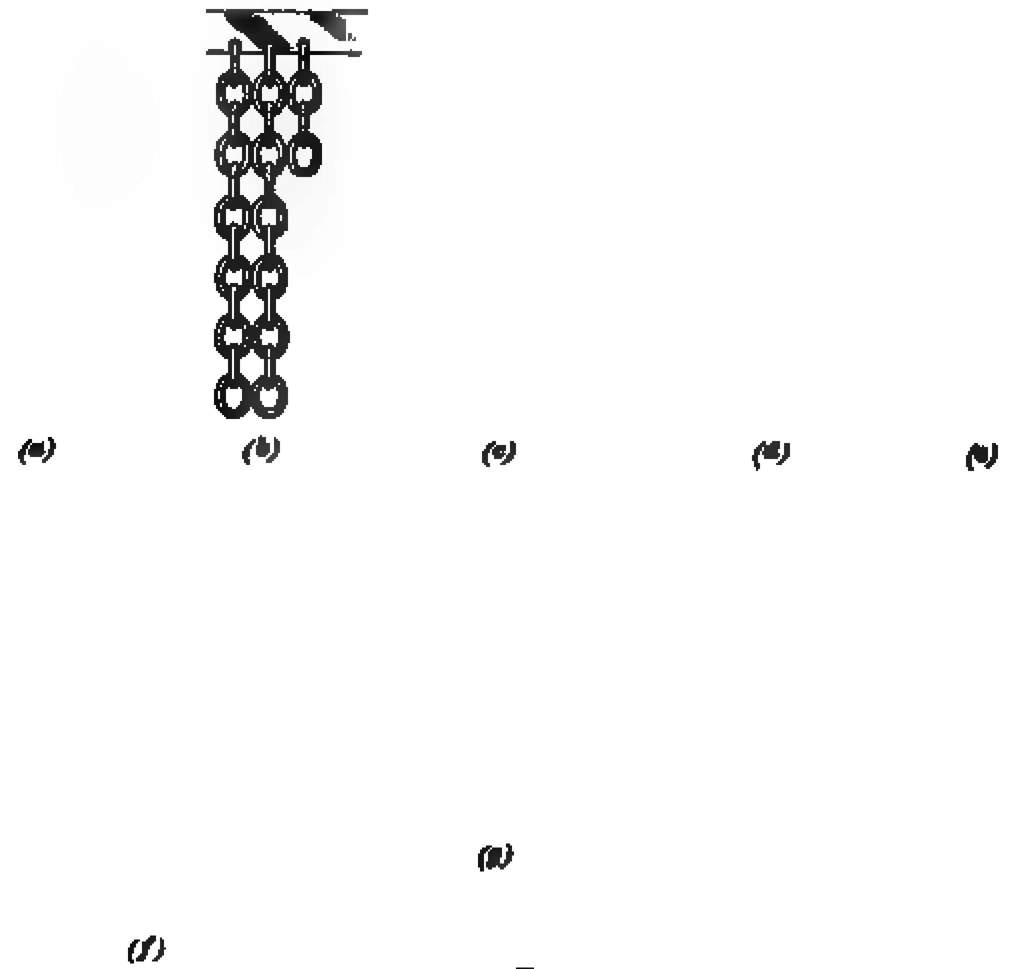


Fig. 44

opalescent glass of different colors being usually employed. In some localities where pieces large enough to fit the frame can be obtained, mica is more popular than transparent glass.

47. Beads and Glass Balls.—Electric bulbs and glass balls are frequently ornamented by means of cut beads strung on wires. Very good effects are sometimes obtained in this way.

48. Fringing.—The fringing for dining-room and library fixtures are various, almost anything to suit the fancy being used. A few popular styles are shown in Fig. 44. At (*a*) is shown a metal chain fringing having S-shaped links; and at (*b*), one having oval links; at (*c*) is shown a fringing made of silken tassels; at (*d*), metal beading on wire or silk threads; at (*e*), glass beads; at (*f*), silken ropes and threads; and at (*g*), art glass or mica incased in a metal frame. At (*h*) are shown some forms of prismatic glass used as fringing, which are again coming into extensive use.

ART GLASS

49. Making Art Glass for Shades.—The general method of manufacturing art glass is as follows: Pots containing glass of the different natural colors are placed beneath openings in a brick oven shaped like a beehive. The colors necessary to form the desired shade of glass are dipped from the pots, with ladles, and poured, through a funnel, on a steel slab. Here the mixture is manipulated with a trowel until it is smoothed somewhat and has approximately the desired consistency. It is then run through a roller located at the end of the steel slab, which gives it the proper thickness and at the same time imparts a smooth or rough back to the glass, as desired. The plate, or panel, of glass is then placed on another steel slab, where it is allowed to cool, after which it is ready for shipment.

The mixing of the natural colors to form the various kinds of art glass is a secret that is jealously guarded by manufacturers, and differs widely in the various concerns engaged in this work.

50. Shaping Art Glass.—Art glass highly ornamental in appearance comes in sheets or panels. When a certain shape and size is desired, the glass is cut to the required size and placed in a sheet- or cast-iron mold. A quick method of bending these sheets is as follows: The mold containing the glass having been placed in a sheet-metal box, a flame, composed of gas and air is played lightly on the glass until it

becomes hot, when the intensity of the flame is increased by means of air pressure. The glass is then pressed on the metal mold with a steel tool resembling a poker, after which it is allowed to cool. Great care must be taken in removing the glass from the sheet-metal box, as a current of cold air or draft will cause the glass to crack.

Double, or **S**, bends, while difficult to execute, are at times attempted in one piece, but owing to the danger of breakage, the general process employed is to make **S** bends in two pieces. These pieces are afterwards joined with ornamental bands, and do not detract from the general appearance of the finished article.

51. Color and Finish of Art Glass.—With the exception of ruby and opal, all colors of art glass bend readily. The former is one of the most difficult colors with which to effect a bend so as to retain the natural, or ruby, color. Often, in the process of bending, this color is lost by heat. All ruby glass contains a large amount of gold, but some manufacturers manage to obtain an excellent color with a small amount of this metal; so that if a bend is attempted the gold is dissipated and the color is lost. Glass of an opal color is very brittle in character, and is subject to a large amount of breakage. It is not an infrequent occurrence to break a number of panels before the desired shape is successfully produced.

In endeavoring to obtain a satin finish in glass, sand should not be used, as the pressure of the sand so weakens the glass that it breaks easily. This is especially true of Etruscan glass, which is very thin, has little body, and is drawn tighter than ordinary glass. The best way to obtain a satin finish is by the use of acid. While a satin finish really makes the glass rough to the touch, it presents a smooth, neat appearance.

CEILING LIGHTS

52. Chandeliers having short stems or no stems at all are called **ceiling lights**. As these lights are generally straight electric, they are controlled by switches or switchboards, the switches being used in private houses and located

at convenient points in the walls, and the switchboards in churches, theaters, and public buildings.

53. Examples of Ceiling Lights.—In Fig. 45 is shown a one-light ceiling fixture that is constructed the same as a one-light electric pendant; it is furnished with a screw canopy.

FIG. 45

FIG. 46

Fig. 46 shows a one-light ceiling fixture constructed with a spun shell and furnished with a ground-glass globe, or ball. The spun shell is placed on the ceiling and is held in position by a holder *a*, which in turn is secured by the connection of the hickey with the insulating joint. The globe, or ball, is held in place by setscrews on the shell.

FIG. 47

54. A cluster ceiling light with a spun shell and a ground-glass dish is shown in Fig. 47. The spun shell *a* is held in position by a holder *b* that is secured by the

connection of the body with the insulating joint. The ground-

Fig. 48

glass dish *c* is used to soften the intensity of the light and is held in place by setscrews in the spun shell.

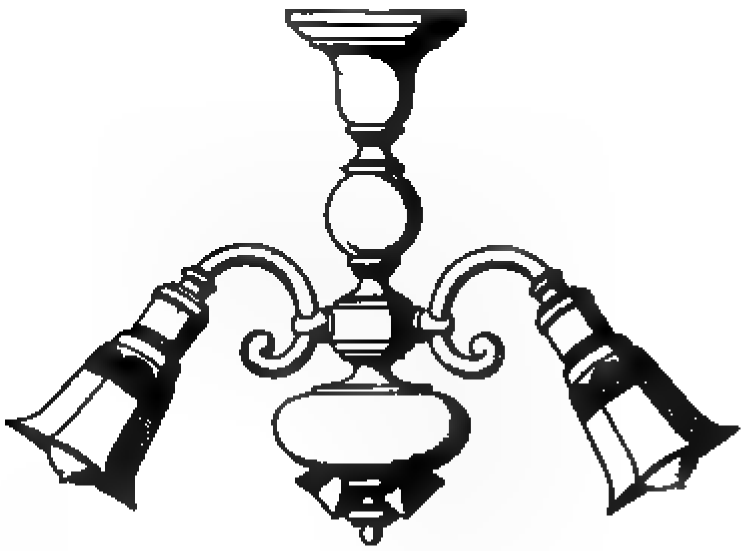


Fig. 49

Fig. 48 illustrates a ceiling fixture that is constructed practically the same as that shown in Fig. 47; it is furnished with a Holophane shade, or reflector, *a*.

Fig. 49 shows a ceiling fixture that is made in practically the same manner as an electric chandelier provided with bent arms.

55. Carved Wooden Ceiling Lights.—A carved wooden ceiling fixture with depending electric-light globes is shown in Fig. 50. Air-dried hardwood with every vestige of moisture extracted is used for this fixture, and as its size ordinarily precludes the possibility of manufacturing it in one piece, for large hardwood timber is scarce, it is made up in sections. These sections, or blocks, are glued together to form the body, being placed crisscross in grain so as to prevent the possibility of cracking or splitting. When the body has been carved, it is usually gilded, which effectually hides all the joints that were formed by the blocks.

As shown in the illustration, the construction of the wooden ceiling light requires a wooden body with metal husks *a* at the corners, in which to place the lights, and a separate pendant knob. The lamps are held in position by brass tubing *b*, which is secured with locknuts as shown. The wiring is made from the insulating joint, passing freely through the brass tubing, and connecting to the socket of the lamp which is screwed to the bottom end of the tube. The pendant knob *c* is of carved wood, and is provided on top with a threaded iron flange *d* that is secured to the knob by three woodscrews. This flange is screwed to an iron pipe *e* that connects with the insulating joint, and thus holds the ceiling fixture in position.

FIG. 50

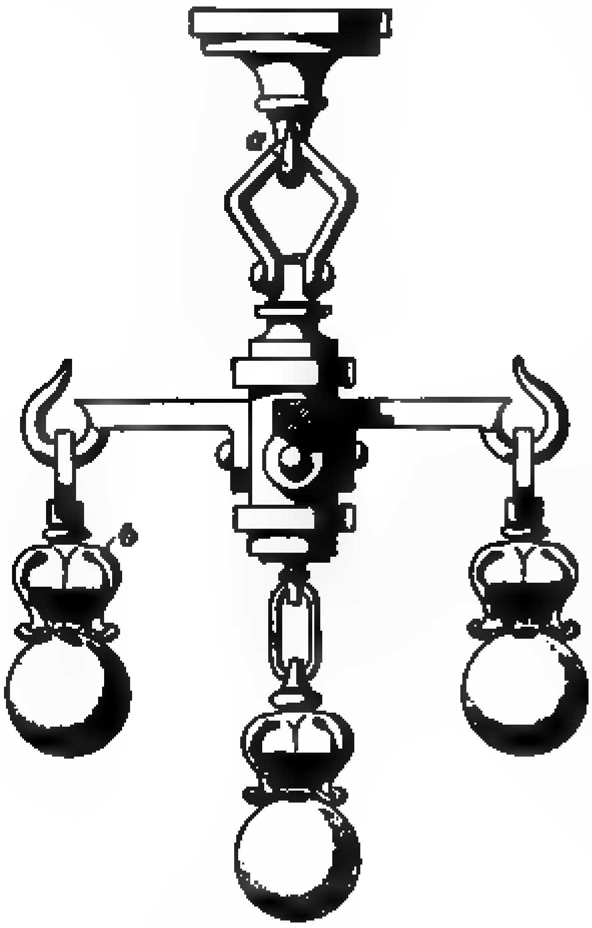


FIG. 51

56. Hammered-Iron Fixtures.—A **hammered-iron ceiling fixture** having all parts square in section is illustrated in Fig. 51. The construction employs a canopy with a hook fitting *a*, a diamond-shaped loop, a body, four hook arms on which hammered-iron husks *b* are suspended by means of links, and one center light. The diamond loop is welded to the hook fitting under the canopy, and the body of the fixture is made of wrought iron; the arms also are of wrought iron and are riveted to the body. The links on the ends of

the hook arms are provided with a fitting to which the hammered husks are connected. The center light is supported by a link fitting that screws to the body. The whole fixture is held in position by an iron pipe that connects with the insulating joint and the hook fitting under the canopy. This fixture is wired in the same manner as an ordinary electric chain-stem fixture.

FIG. 52

57. Lantern Fixtures.—Fig. 52 illustrates a **lantern ceiling light** made up of a canopy having a hook fitting and a semielliptic loop that is riveted or screwed to an octagonal lantern. This fixture is wired in a manner somewhat similar to chain-stem fixtures, the only difference being that the wires are connected directly to the socket from the tripod or insulating joint.

FIG. 53

58. Hammered-Brass Lights.—In Fig. 53 is shown a **hammered-brass ceiling light** consisting of a hammered canopy, a ring chain, a hammered body with cast arms finished in imitation of hammered metal, and two hammered hoods having shades composed of mica in brass binding. This fixture is made of about No. 12 gauge metal and is built up in sections. The sections are first cut to the size and pattern desired and then

hammered, an operation that requires much skill in order to give the parts a perfect finish and form, after which they are bent to shape and then riveted together. The wiring of this fixture is the same as that employed for Fig. 51.

59. Crystal Ceiling Lights.—A **crystal ceiling light** made up of brass bands fringed with glass prisms is illustrated in Fig. 54. The body of this fixture is constructed with five horizontal bands *a*, which are held in position with four or five vertical straps, as shown at *b*. The top is a spun shell, which is fastened to the insulating joint and the vertical strap. The glass prisms are attached to the bands by metal hooks formed by the wire passing through the prisms. All inside metal work of ceiling lights that are provided with crystal prisms should be of plated nickel or silver, so as to insure proper reflection of the light. This treatment also provides metal work that is nearly the same general color as the prism.

Fig. 54

CANDELABRA

60. Introduction.—The **candelabrum** was, as its name indicates, primarily used to bear or hold candles and has a socket or pricket on its end. When lamps replaced candles, this fixture underwent no material change in appearance or construction, the lamps being placed on the socket or on arms connected to the stem. Some candelabra were furnished with hook arms on which the lamps were suspended by chains. In houses of worship and at shrines, candles were always used in candelabra.

61. Construction.—The important parts of the candelabrum, or **standard,** as it is commonly called and which

is the name that will be used here, are the base and stem, though arms and clusters of lights are also supplied. Standards are either set on pedestals and newel posts or are connected directly to the floor or ground, those set in front of houses, monuments, etc. being placed on a stone base. Standards intended for indoor illumination are usually held in position by lighting connections only, whereas standards that are used in the open air must be secured by bolts to the base of porches, stone pedestals, or other suitable bases. Expansion bolts are generally used for holding a standard in position, connections being made through the bottom of the standard and into the base. Standards are always furnished with a globe or lantern.

62. Bronze Standards.—In Fig. 55 is shown a sectional view of a **bronze standard** that may be adapted to either outdoor or indoor illumination. Connections are made at the base, and when the standard is mounted on a stone base, or on a pedestal, the wiring is made through iron pipes. The end of the piping projecting through the base or pedestal is fitted with an insulating joint *a* to which the iron pipe *b* that holds the stem in position is connected.

A spun shell *c* is connected to the pipe above the hickey *d*, and is held in position by the electric body *e*, being

FIG. 55

secured to the pipe connected to the hickey, and on which the cluster of lights is arranged. The shell is used to protect the connections and the interior of the standard from rain or water with which the globe or standard may be cleaned. The globe holder *f* is furnished with small holes equally distributed around its circumference, through which the water falling on the globe, or shell, passes off the standard and falls to the ground. Standards should be constructed with a view to making them as nearly water-tight as possible.

63. Cast-Metal Standards.—A **cast-metal standard** for either interior or exterior illumination is shown in Fig. 56. This standard consists of a base made of three claws, or feet, a stem, a body, or plate, and husks and lamps.

An iron pipe having screw nuts adjusted at the top and bottom is used to hold the stem and body in position. The pipe is run inside the stem and extends through the body, which is fastened by screwing the nut to the top end of the pipe. The outer lights are placed on the body, and the center light is attached to the top of the plate, which is fastened to the body with screws.

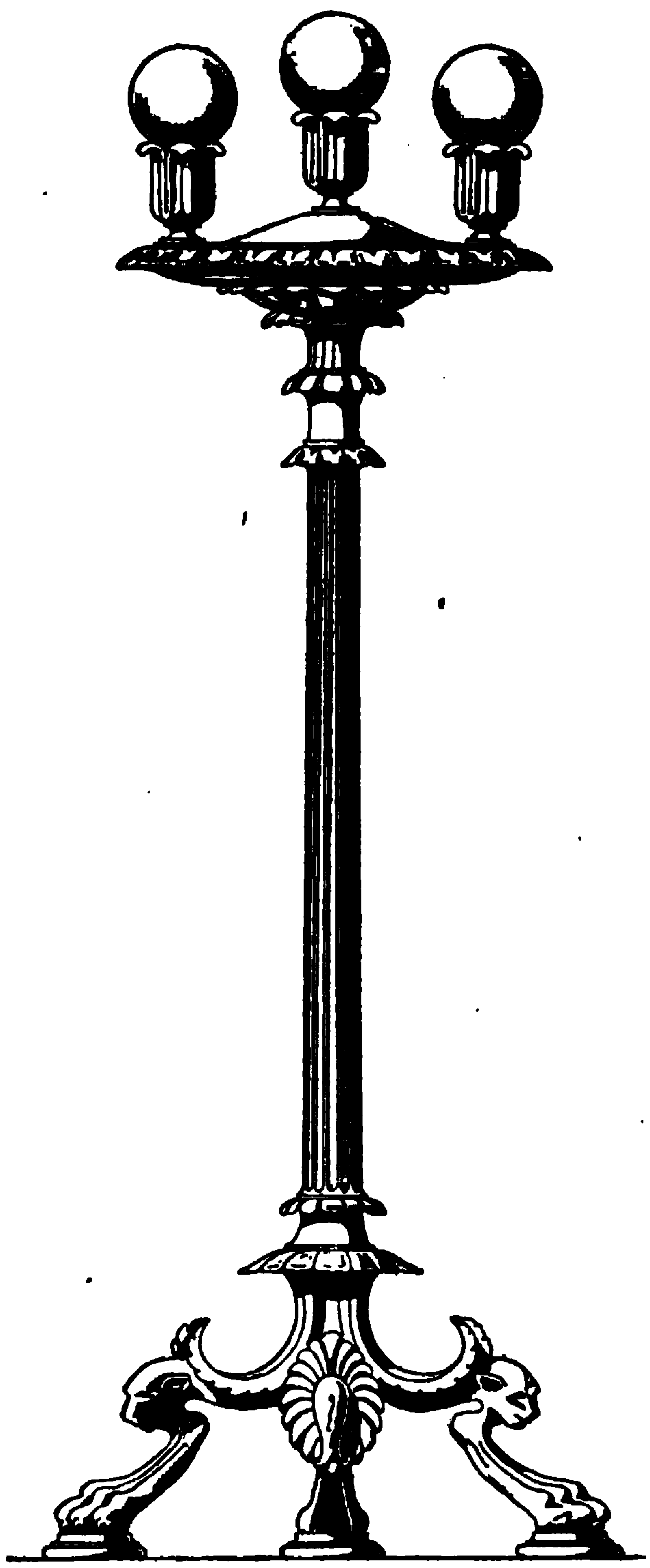


Fig. 56

This plate must be removed when wiring for the center light, and the wires used should be long enough to permit its removal and allow connections to be made.

64. Newel Light.—In Fig. 57 is shown a **newel light**, which is simply a standard mounted on a newel post. This standard is made of carved wood, and is secured to the post by wood screws, which are inserted through a tripod *a* in the base. The wiring is done through this tripod, and the iron pipe that holds the stem in position. The fitting *b*, which acts as a globe holder, is made of cast brass, and is screwed to the iron pipe, this connection holding the standard in position. The fitting in this light is made of metal because a wooden fitting would not be strong enough.

65. Other Designs.—In addition to the illustrations given, standards may be arranged in other practicable forms. Thus, gas standards are provided with one or more lights, as, for instance, city lamp posts; or they are provided with a profusion of lights, as when used in churches or auditoriums. When used for interior illumination, gas standards are generally provided with porcelain candles, those in churches being of white porcelain and having the appearance of a straight candle, while the colored porcelain candles of spiral shape are sometimes used in public halls and private dwellings.

Fig. 57

Electric standards may be arranged with a number of lights springing from husks set at four corners of the stem, and having a center illumination of electric lights incased in a ground-glass globe. This globe can be held in position by a cast-metal band secured to the cap or top of the stem, which could be made somewhat like an Ionic capital. It will not

be necessary to give a detailed description of the different designs of any fixture, for new features in the ornamentation and arrangement of lights are brought out each day. But these all conform to the general principles that have been given.

Gas newel lights are constructed with one light or with separate arms set or connected to the stem in a straight line; or, they are made with a cluster of lights arranged on a gas body around a center light, or the center light may be discarded and a cast-metal or spun shell substituted and held in position by a finial knob screwed to a wire connecting to the gas body. Electric newel lights are sometimes provided with a crimson-glass shade resembling the flame of a torch, the illumination being made with one light. A fixture of this description is more ornamental than useful and it illuminates with a truly artistic effect.

66. Combination Lights.—Combination standards and newels must be provided with the extra iron pipe, or conductor, for the wires. If the gas light or lights are placed on top of the stem, they are connected directly to the gas body and the electric lights around the stem are connected to the wires. When gas and electric lights are placed around the stem on the same circle, the combination body must be used, and a cast ball, or sphere, surmounted by a finial knob may be placed in the center; or, the ground-glass globe arrangement of lights previously described may be substituted for the metal sphere. A combination arrangement that permits the use of combination arms may also be applied to standards and newel lights. It should always be borne in mind that standard and newel lights are identical; the latter merely identifies those standards that are mounted on newel posts.

67. Portable Table Lamps.—Table lamps, or **portables**, are—as their name suggests—fixtures that may be moved about anywhere within a radius equal to the length of the wire connection or gas tubing that may be attached to them.

Fig. 58 illustrates an **electric table lamp** consisting of a base *a*, a gooseneck arm *b*, and a sea-shell shade *c*. The base, which is made of cast metal, has its interior filled with lead so as to give it increased weight. This is very necessary because the end of the gooseneck arm fitted with the shade extends at least 8 inches beyond the center of the base, and if the center of gravity were not thus taken care of, the weight at the end of the arm would cause the fixture to topple over. This gooseneck arm is brazed to the base and is furnished with a fitting that supports the shade. The shade is made of translucent glass, which is cast in a mold that gives it the form of a sea shell, and the surface of the shade is then etched, thus giving a satin finish, which produces a soft diffusion of light. As shown at *d*, the wiring is made through a socket at the base. This socket is furnished with a vulcanized-rubber bushing, which serves as an insulator in case the covering is stripped off the wires, and thus prevents the bare wire from touching the metal of the fixture and causing a short circuit, or ground. The portable shown in Fig. 58 has a rigid neck, though flexible necks that permit the light to be arranged at any angle desired are in common use—desk portables, for instance, being almost always made flexible.

FIG. 58

68. Gas table lamps, or portables, consist simply of a base, a stem, and a burner, and the base or the stem is fitted with a cock, to which the gas hose is connected. Mica or glass chimneys are used to protect the light, which is reflected on the table by a glass or porcelain shade. The glass shades most commonly used have a green-colored exterior and a white interior

69. Gas Candlesticks.—Ever since the introduction of the candle for lighting purposes, the candlestick has been the

universal candleholder. With the exception of dimensions, the candlestick resembles the standard in all respects, the proportion of the latter to the former being about as 1 is to $2\frac{1}{2}$.

In Fig. 59 is shown a cut-glass candlestick having a base made with an opening in the bottom to provide space for a stiff joint *a* on the gas outlet. The section *b*, called a *break*, interrupts the connection of the glass stem with the base, and a lever cock *c* on the stem controls the supply of gas to the arms, which are made of glass. The twisting and turning of a cock, if placed on a glass arm, would, in a very short time wrench the arm from its fastening, thereby ruining the fixture, which could not be repaired in a satisfactory manner. A cut-glass dish *d* with a fringing of prismatic glass conceals the lever cock, and the arms of the fixture are secured to silver-plated fittings *f*, by plaster of Paris, these fittings being used to connect the arms to a body fitting on the stem. The end fitting *e* on the arms is secured in the same manner as the fitting *f*. A silver-plated spun shell *g* holds the candle *h* in position, and the finial knob is secured to a fitting on the end of the stem.

Fig. 59

All metal fittings in this candlestick are silver or nickel plated—a color that blends with the crystalline clearness of the glass. Cut-glass fixtures require a certain delicacy in handling and mounting, and great care must be taken to see that they are perfectly gas-tight—that is, free from any leakage—when they are installed. This is best ascertained by thoroughly testing every part of the fixture in the shop or factory previous to delivery to the purchaser.

70. Electric Candlestick.—A cut-glass candlestick may be made into an electric fixture by fitting it with proper

connections. A like number of arms as in the gas fixture can be supplied, and in addition to providing the glass dish on the stem with a glass fringing, a fringing can be placed at the end of each arm. The best effects of the lamp fringing are obtained by placing the lights so as to divert the illumination downwards. Cut-glass candlesticks can also be provided with combination bodies.

Electric candle lamps are made principally of transparent and frosted glass. When a soft-colored reflection of light is desired, the candlestick is provided with silk shades, which produce a very artistic effect. Frosted lamps, on candlesticks, also present a very artistic appearance, and burn with a bright, white light. They are placed on mantels or cabinets, and, when illumination rather than ornamentation is desired, are very serviceable. The rough outer surface of these lamps, which resembles a frosted window pane, is produced by placing them in an acid bath.

71. Frosted lamps are made in various forms; some have the exact shape of a candle, some of the standard form given to incandescent lamps, while others are made with elongated spiral curves, representing the flame of a candle. The latter is illustrated in Fig. 60, where the candle flame *a* is connected to a socket *b*, which is placed in a porcelain candle *c* fitted to the arm of the fixture.

FIG. 60

The candle tube *d* is screwed to the end fitting on the arm of a fixture, and the socket *b* is screwed to the tube, the thread being soldered so as to get additional strength when making a safe, rigid connection. The connection must be made secure and stiff in order to prevent the socket from turning through handling the fixture, thereby protecting insulation on wires from being worn or cut.

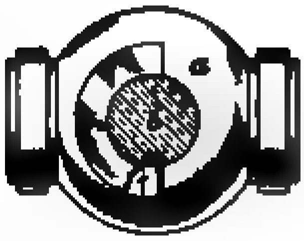
COCKS AND FITTINGS

72. The construction of a **common gas-cock** for a fixture arm is shown in Fig. 61 (*a*), (*b*), and (*c*), and consists of a body and key with a washer and screw. The body *a* is turned out of bar metal, and the key *b* is cast and fitted to the body, the washer *c* and screw *d* being fastened on the key to hold it in position. The body is also drilled and threaded on each end at right angles to the key fitting, and thus provides a passage *e* for the flow of gas. In the under part of the body, which is shown at (*a*), is placed a check to regulate the movement of the key. A hole *e* for the passage of gas is drilled through the key, which is also furnished with a pin *f* that comes in contact with the check on the body when the supply of gas has been turned off. At (*b*) is shown the position of the key when the gas is shut off, and at (*c*) the position when it is burning.

73. A **concealed cock,** which is employed in the construction of lanterns, dining-room and library fixtures, etc., is shown in detail in Fig. 61 (*d*). It is used on arms that occupy the position of combined end fitting and cock, and also on all fixtures where the flow of gas must be converted from a horizontal to a vertical direction while passing through the key. The body of the concealed cock is turned out of bar metal and the key is constructed practically the same as an ordinary gas-cock key, except that the screw holding it in position is drilled as shown at *a* so as to permit the passage of gas through the nozzle *b*. This nozzle is turned out of bar metal, and is screwed to the body as shown.

74. In Fig. 61 (*e*) is shown a **gas swing joint** that is constructed with one cast and one turned-metal fitting. The arm is connected to the turned-metal fitting, and the cast fitting is held in position by a screw and washer the same as a key.

75. A **straight-electric swing joint,** which is constructed with a cast fitting, a turned-metal fitting, and a metal bushing, is shown in Fig. 61 (*f*). The cast fitting is held in



(a)

(d)

(g)

(e)

(f)

Fig. 61

position by a perforated screw *a* and a washer *b*, and the bushing, or plug, *c* is employed to conceal that part of the fitting which was drilled to allow the screw and washer to be placed inside. Wires are run through this fitting as shown at *d*, and when they are inserted through the fittings, the bushing *c* is unscrewed so as to permit the wires to be pulled taut. After the wiring is completed the bushing is readjusted.

76. A combination end fitting turned out of bar metal is shown in Fig. 61 (*g*). This device combines the practical illumination by gas and electricity through connections on one fitting, the gas passing through the iron pipe *a* and the wires through a covering tube *b*.

77. Gas Igniters.—The object of an **igniter** is to automatically ignite the gas as soon as it is turned on. This is accomplished in two ways: (1) by allowing a small quantity of gas to burn constantly inside the lamp; and (2) by producing a flame or spark that will automatically ignite the gas when it is turned on. The former is the simpler, cheaper, and more common plan. Igniters are used for lighting gas burners either singly or in groups, and are designed to save the time and labor that would be required to light them by hand.

78. A self-lighting gas burner is shown in Fig. 62.

The key is so made that the gas can never be entirely shut off, and when it is turned to extinguish the light, enough gas is allowed to pass to maintain a small *peep* of flame at the tip of the burner. In order to prevent this flame being extinguished by drafts of air, it is enclosed by a cap, or globe, *g*.

FIG. 62

When the burner is in full operation, the globe drops below the flame to the position shown; but when the lever *b* is reversed to shut off the gas, the link *d* raises the globe above the top of the burner, thus shielding the little flame. The

lower end *a* is a socket, threaded and soldered to fit the ordinary fixture. The fixture to which this burner is attached must be provided with a key, as usual, so that the burner may be entirely turned off if desired.

79. Sun lights, and other large groups or clusters of burners, are usually lighted in a similar manner. When the lights in a cluster are extinguished, one small tip is left burning, and serves to relight the whole group when the gas is again turned on. This burner is commonly called a *pilot light*, and it is supplied with gas by a separate pipe. The supply of gas to all the other burners is controlled by a single cock, so that they may be turned down simultaneously and may be extinguished or promptly relighted whenever desired.

A large number of electric igniting devices use one of two methods: In some, an electric spark is caused to flash through the stream of gas issuing from each burner, thus igniting it; in others, a small piece of platinum wire is heated to incandescence near the tip of each burner, the electric current being turned on after the gas issues from the burners and shut off as soon as the lights appear.

80. Gas Shields.—The space between an ordinary gas burner and the ceiling should be not less than 3 feet. If a smaller distance is unavoidable, the ceiling should be protected by a metal shield to prevent its being scorched or burned. The shield should be separated from the ceiling by a clear space of at least 2 inches, to permit air to circulate between them. Even when a shield is provided, a gas flame should not be permitted at a smaller distance than 18 inches below the ceiling.

If a gas flame is liable to come into accidental contact with inflammable materials, such as curtains or drapery blown by the wind, or hay and straw in stables, etc., it should be provided with a glass globe and enclosed within a stout wire cage at least 10 inches in diameter. The only safe way to determine the proper size of the wire guard is to make tests by holding pieces of cloth or paper against it. If the material can be set on fire, the guard should be made larger.

81. The *discoloration* of *ceilings* may be partly if not wholly remedied by using a *deflector*, or by hanging an ordinary *smoke-bell* over the flame. By spreading out the current, its velocity is checked, the amount of dust that strikes the ceiling within a given area is thus reduced, and the discoloration is lessened.

The only *effectual* method of preventing the discoloration of walls and ceilings in this manner is to intercept the current of hot air rising from each burner and to conduct it to a chimney or ventilating flue by means of a hood suspended over each flame, or set of flames, and suitable pipe connections. This plan is valuable for another reason. Not only are the products of combustion removed from the room, but a considerable amount of air is carried along also, thus aiding ventilation. The hot gas discharging into the ventilating flue raises the temperature therein, and thus increases the draft and improves the operation of the flue.

CONSTRUCTION OF LIGHTING FIXTURES

METHODS OF MANUFACTURE

SHOP AND FOUNDRY WORK

82. Materials.—The manufacture of fixtures of all descriptions involves the use of many metals and their alloys, glass, plaster composition, and wood.

Brass is a yellow-colored compound metal consisting of an alloy of copper and from 24 to 37 per cent. of zinc, with very often a small portion of lead and tin being added. Brass is harder than copper, more fusible, and not so good a conductor of heat. Its value in the manufacture of fixtures is due to these qualities.

Bronze is a brown alloy, or mixture, composed of 87 parts of copper and 13 parts of zinc. As it is harder and more fusible than copper itself and oxidizes slowly, even when

the air is moist, it is well adapted for fixtures and assures durability, in addition to which, its appearance is highly ornamental.

While *iron* is used in making fixtures, it is not extensively employed, as it cannot be prevented from oxidizing under the influence of the atmosphere. In spite of all known protectors, such as paints and burning with oil, which clog the pores of the iron, it is impossible to prevent rusting.

Spelter is a mixture of tin and zinc. It was formerly used in making fixtures, but, on account of its brittleness, has been practically discarded. When fixtures made of spelter are once broken, they cannot be easily repaired.

Cut and pressed *glass* are occasionally employed in the manufacture of fixtures.

83. Plaster composition is a mixture used by fixture makers for modeling purposes. The manner of mixing and the constituents employed are almost as numerous as the fixture concerns themselves, and nearly every manufacturing concern possesses its secret recipe, which is jealously guarded. The principal recommendations of plaster composition lie in its cheapness and the fact that, despite the comparatively low cost, excellent effects can be produced with it. One method of making it is to mix together resin, glue, whiting, linseed oil, and cocoanut fiber. A cast of this material is made by placing the mixture in a heated condition into a plaster-of-Paris or wooden mold. This plaster-of-Paris mold can be used for from six to ten casts but the wooden mold may be employed indefinitely.

84. The use of *wood* in the manufacture of fixtures, an innovation introduced by the old Italians, has become quite popular within the past few years because of a desire for antique effects, since the ravages of time can be more easily imitated in wood than in metal or in plaster composition. The worn and time-eaten effects in wood are produced artificially and with such fidelity to detail as to almost defy detection. By the hands of skilled carvers, the wooden fixtures installed in some of the finest dwellings in the

United States have been made to assume an appearance similar to that imparted to the wood by long service.

85. The Mold.—When molten brass or bronze is run into a suitable receptacle, or mold, and allowed to cool and solidify to the resulting object, the term *cast brass* or *cast bronze*, as the case may be, is applied.

A **mold**, therefore, is a receptacle, or matrix, into which molten brass or bronze is poured and given the form desired. The mold is made by impressing in sand one or more cavities representing in outline and general detail the object to be cast. Making the impression in the sand is called *molding*, and it is effected by means of a model, or pattern, which is pressed into the sand in such a manner that, when withdrawn, an imprint of its surface and outline in detail will remain.

86. The Model.—As a preliminary to the work of casting, a **model** that represents the contour and ornamentations of the casting desired is prepared. The general method employed is to first shape the entire fixture in clay, and then cast each part in plaster of Paris, thus obtaining a negative, or mold, of the clay model. This negative is then allowed to dry, and after being lacquered, or oiled, is filled with a thin mixture of plaster of Paris and water, which is run in before the plaster has set. A positive, or plaster-of-Paris, model identically the same as the clay model is thus obtained. It is cut with tools to make it as clear and sharply defined as possible.

This plaster model may be used as a pattern, but if an *applied pattern* is desired, it will be necessary to make a negative of this sharp-cut model in the manner just described. Modeler's wax is then rolled into the form of a plate having a thickness equal to that of the metal desired in the casting, and this wax plate is pressed into the negative, after which the center of the mold is filled with a mixture of plaster of Paris and water. After the plaster has set, the two parts of the plaster mold, consisting of the negative and an imitation positive, are separated, and the wax is removed. The imitation positive is then replaced, and an opening is made

between the two parts of this plaster mold. Melted wax is then run in, a cast of the form required being thus obtained in the wax. After the wax has become cold, the plaster mold is opened, thus disclosing the wax pattern, or model, which has the same thickness as is desired in the metal casting.

At times, models are carved in wood, and the weight of the casting may be approximately determined beforehand by multiplying the weight of the model by 16 if hardwood is used, and by 18½ if soft wood is used. All models are treated to a coating of shellac to prevent them from adhering to the molding sand.

87. Casting.—After the model is completed, a metal cast of the object desired may be made. Casting consists in pouring molten metal into a sand mold. In manufacturing fixtures, the molding box, or *flask*, which contains the molding sand, is always made of iron, and is also provided with openings, called *gates*, that allow the molten metal to enter. This box has two sections, which present the form of an oblong or square frame, but is constructed with only four sides; the openings are either on the ends or the sides. The lower portion, or drag, is placed on a board, and sand is put into the frame and packed as tightly as possible with a rammer, or billet, resembling a wooden potato masher, but with one end about 4 inches wide and 1 inch thick. When the sand has been firmly packed and leveled to the top of the drag, the pattern is put in, being placed as close as possible to one or more of the openings. The cope, or upper section, is then filled and packed with the sand and placed on top of the drag, being secured by flask pins inserted through ears with which both sections are provided. A layer of charcoal is distributed over the surface of the sand to prevent the sand in the forms from adhering together when the sections of the flask are separated.

When the impression in the sand has been made, the cope is taken off and the pattern removed. Channels from the mold to the openings are then made in the sand, after which

the cope is readjusted and again secured with the flask pins. The flask is then sandwiched between two flat boards, which are tightly held in position by flask clamps, and when the clamps are secured, the boards with the flask are placed on end and the molten metal poured in. When the metal has solidified, it is removed from the mold.

88. A preliminary casting, called the **pattern**, is made from the model, and is used for making impressions for all subsequent castings of the same object. This preliminary cast, or pattern, is always fashioned out of brass of the finest quality, and it is filed and chased, if necessary, before being used for making an impression in the sand. Fine casts are thus obtained, and much time and labor in filing and chasing afterwards are saved.

In making castings in brass or bronze, a small allowance is made for shrinkage, as contraction, or decrease in size, results when the metal run into the sand mold in a molten condition is allowed to cool. The general rule is to allow $\frac{1}{65}$ of the length for shrinkage for brass, and $\frac{1}{84}$ for bronze.

The tendency of the model, or pattern, to cling to the sides of the sand mold and thus destroy its clean, sharp contour is very great; therefore, in order to overcome this tendency, the sides of the mold, or pattern, are always slightly beveled. No general rule of the amount to be allowed for taper can be given, as it varies considerably and is altogether dependent on the character and style of the object to be cast.

89. In casting objects of an elaborate character, that is, those in which scrolls, etc., predominate, precaution must be taken when withdrawing the model to prevent tearing out part of the sand and thus destroying the mold. Outside cores made of fine yellow sand and corresponding to the different parts of the model are used for this purpose. They are separated from one another with thin layers of charcoal, which enable them to be picked out separately, thus affording an opportunity to withdraw the model without injuring the mold. When the model has been withdrawn, the cores are

put back into position uninjured, as the sand used is so adhesive in character that it will allow this to be easily effected. A perfect mold is thus secured, and the molten metal may be poured into the gates of the molding box as before described.

The necessity of using outside cores is obvious when the casting of an object—such, for example, as a clenched hand—is desired. The making of a mold of this character cannot be accomplished in the ordinary manner, as the interstices, or hollows, between the thumb and forefinger and at the outside of the hand near the small finger will tear away part of the mold if an effort is made to withdraw the model. These outside cores, which are their own support, can be taken out separately, and the model may thus be withdrawn without harming the mold, which is again complete when the cores are placed in position.

The method of casting has been described with reference to the making of a pattern, and differs in no respect from the process used in forming duplicates of the pattern. On account of its durability, in the molding room, the brass pattern replaces the models mentioned in the description heretofore given.

MAKING UP THE FIXTURES

90. The departments through which a fixture goes before it is really completed, the processes employed, and the relation of each department in turning out a fixture, will now be briefly described.

The various materials employed in making a fixture are kept on hand in the stockroom, where are also stored the castings that are practically always in demand. Finely chased patterns are placed in a vault in this room, and are kept from coming in contact with one another, as mere contact is sufficient to destroy the effects of the chasing.

91. Cleaning Castings.—From the stockroom, castings are taken to the filing department, where the burrs are removed by an emery wheel and the best steel files. The

emery lathe used to remove the roughness from scrollwork consists of a thin canvas strap coated with powdered emery and two wheels—one large and one small—over which the strap is placed. Power is furnished by a power wheel and belt connected to the lathe. In finishing the scroll, the strap is run in and around each part, the thoroughness with which the work is done depending, of course, on the skill of the operator.

92. Fittings.—After using the lathe, the fixture is taken to the chandelier department where the required fittings are turned, all necessary holes drilled, and threads put on where desired. Cock fittings are made in the cock room, the manufacturing of this special fitting, in fixture making, being considered as a distinct part.

When turned cocks and fittings are required in large quantities, an automatic lathe Monitor is employed. Fixtures are made rapidly and economically with this machine, for after a bar of metal is once set, the lathe will continue its work without the operator's assistance until the bar of metal is used up. One operator may successfully run from four to eight lathes of this type.

93. Bending and Brazing.—The arm makers then take the fixture in charge and do all necessary bending and brazing. In bending an arm with a long sweeping curve, the tubing is filled with sand, and then corked on both ends to prevent the sand from escaping. In more difficult bends, that is, where the sweep of the curve is shorter, the tubing is filled with melted resin, and after the desired bend is obtained, the resin is reheated so that it may be poured from the tubing. For very short bends, the tubing is filled with molten lead, which is removed after the bend is made by again heating and melting it. Filling the tubing in this manner when the bends are to be made prevents kinks and bruises. Ornaments are placed on tubing by arm makers when it is desired. Before brazing any part of a fixture, it must be thoroughly cleaned. It is then placed over a fire, where powdered borax is used to prevent the metal from oxidizing, after which

brazing solder is applied. Brazing solder is a very soft brass, the softness being obtained by increasing the quantity or zinc or spelter in mixing. This solder will therefore melt under the influence of heat more quickly than the metal that is to be brazed. A soft solder instead of spelter solder is sometimes employed for connecting fittings.

94. Shell Spinning.—After bending and brazing, the fixture is consigned to the spinners, who spin all shells required. In spinning, a wooden or metal pattern called a *chuck*, or *block*, corresponding in shape with the shell desired,

TABLE I

THICKNESS AND GAUGE OF METALS

Gauge Number	Thickness Inch	Gauge Number	Thickness Inch	Gauge Number	Thickness Inch	Gauge Number	Thickness Inch
5	.182	13	.072	21	.028	29	.0110
6	.162	14	.064	22	.025	30	.0100
7	.144	15	.057	23	.022	31	.0090
8	.128	16	.051	24	.020	32	.0080
9	.114	17	.045	25	.018	33	.0070
10	.102	18	.040	26	.016	34	.0063
11	.091	19	.036	27	.014	35	.0056
12	.081	20	.032	28	.012	36	.0050

is employed. This is fixed on a lathe so that it will revolve rapidly. A circular piece of sheet metal is then fastened to the chuck in such a manner that the metal will spin with the chuck. While the metal is spinning, a pressure is exerted on the metal with a smooth, heavy, steel tool, which rests on a bar, or fulcrum, so as to enable the operator to exert the greatest amount of pressure with the least expenditure of energy. This pressure on the metal causes it to buckle or bend at the edges. The metal is then taken from the chuck, heated, and beaten with a wooden mallet until the surface of the end is smooth. After this, it is again heated,

and while in this state is plunged into cold water; it is then placed on the fire in order to dry quickly, and the operation of pressing it against the side of the block is resumed. Heating and beating the metal in this manner must sometimes be done three or four times before the shell is completed.

When a shell having an opening smaller than the diameter is desired, a *split chuck* made of wood is used. The pieces of this chuck are carefully joined together and so arranged that each piece may be easily removed through the opening when the shell is finished.

95. Material for Shells.—The lowest gauge of metal used in spinning shells is No. 22, and the highest, No. 12. In Table I is given the thickness and gauge of metals employed.

96. Assembling.—From the spinner, the different parts of the fixture are again taken to the chandelier maker, whose duty is to see that the different fittings are practically constructed to form a perfect fixture. The chandelier maker joins the different fittings together according to the full-size drawing with which he is provided, and drills and taps, or threads, all ornaments, supplies threaded wire where necessary, and constructs the entire fixture, previous to delivering it to the chaser, polisher, plater, etc.

97. Chasing.—The chaser mechanically engraves all fittings to be chased. All castings that have been cored require chasing, as the core leaves traces of the support it gave to the pattern when in the molding flask. In chasing, the fitting is generally laid on a solid hemispherical block made of lead, while steel chisels, varying in size and shape according to the character of the pattern to be chased, are employed. A skilled chaser should possess a sharp eye and a steady hand, for if he should make a mistake in striking the tool—either too light or too heavy—the impression will be easily noticed. Practically all castings of the finest type are chased.

98. Dipping and Polishing.—When chased, the fittings of the fixture are ready for the dipping department. Each fitting is dipped in potash to remove all traces of grease, and then washed in hot water to get rid of any adhering potash. It is next given a bath in nitric acid to burn off any dirt that may still cling to it, washed in cold water to remove traces of the acid, and then placed in a bath composed of one part of nitric acid and two parts of hydrochloric acid, which gives to it a bright finish. After this, the fitting is again washed in cold water, and plunged into hot water, so that on being removed it will dry quickly; the drying process is also hastened by throwing the fitting into sawdust.

If the fixture is to be enameled, the lacquerers apply the enamel in very thin coats, which are allowed to dry after each application. This process is kept up until a clear, smooth surface is obtained.

The different parts of the fixture are now consigned to the polishers, who cut them down with a wheel about 15 inches in diameter. This wheel, or buffer, has layers of cotton cloth placed on it to the thickness of about 1½ inches, to which a substance known as *triple* is applied. The rough surface of the metal is also made smooth by this wheel. A highly polished finish is then given to the metal by a similar cloth wheel on which rouge (ferric oxide) is applied.

If a brass fixture is to be brushed after passing through the hands of the polishers, it is cut down by a brush wheel and white sand, passed through a cyanide wash, immersed in hot water, and then thrown into sawdust to dry, after which it is sent to the lacquering department. If a finish of polished gilt or brass is desired, the fittings pass from the polishers to the plating department where they are immersed in hot water, placed in a cyanide wash, put into cold water, again plunged into hot water, and then thrown into sawdust to dry. When dry, the fittings are brightened by rubbing with a smooth cloth wheel and given to the lacquerers, who apply the desired finish—lacquer, gilt, or polished brass.

A verd-antique finish, which imparts to the fitting a beautiful green color, resembling the oxidation of bronze or brass long exposed to the influences of the atmosphere, is obtained by putting the fittings through the dipping process just described and applying a paint composed of Paris green, powder, varnish, and turpentine. While the paint is still wet, it is wiped off here and there to permit the brass to show through, and a coat of lacquer is applied to preserve the paint. Every manufacturing concern has its own method for obtaining this finish.

If a satin finish is desired, the fixture is taken to the sand-blowing department, where a rough appearance is given to the surface of the metal by blowing sand on it with great force.

99. Plating and Burnishing.—Before a part or the whole of a fixture can be plated with gold, silver, bronze, or nickel, it must first be thoroughly cleansed. This is usually done in the plating room, where the fixture is dipped in potash to remove all traces of the rouge used by the polisher. It is then immersed in hot water to remove the potash, and after placing in a cyanide wash consisting of $\frac{1}{4}$ pound of cyanide of potash dissolved in 1 gallon of water, it is again put into hot water and thrown into sawdust to dry.

Electroplating is a process of coating a metal or metallic surface by exposing it in a bath consisting of a solution of metallic salt, which is decomposed by electrolytic action. A voltaic current is employed for this purpose, and it is supplied by a constant battery, but if plating is to be done on a large scale, a dynamo is used. The vessel in which the metallic salt is placed must be made of some non-conducting material, as, for instance, glass, stoneware, or wood.

In the simple form of plating, the galvanic current is produced in the same vessel in which the plating is done. The object to be plated is attached to a rod connected to the negative pole of the battery, while the metal to be used in plating—gold, silver, etc.—is connected to the positive pole, both the object to be plated and the plating metal being

placed in the vat where the plating is effected. The plating metal exists in the form of a solution of the metallic salt. By passing a current of electricity through the solution the circuit is completed, and the substance of the plating metal attaches itself to the object to be plated. The thickness of the plating is regulated by the length of time it remains in the solution with the electric current active, and the exact weight of the plating on an object may be ascertained by obtaining the difference in weight before and after immersion. After the operation is completed, the plated article is thoroughly washed in hot water, and placed in sawdust to dry.

If it is desired to plate only a section of an object, the part that is to remain unplated is simply covered with paraffin, sealing wax, varnish, copal varnish mixed with jewelers' rouge, engravers' wax, tallow, beeswax, or shellac varnish, all of which can be easily removed after the plating is completed.

An article is sometimes burnished after it is plated. This process consists in exerting great pressure on the plated object with a smooth steel tool that is dipped into a solution containing licorice. Burnishing imparts a high luster to the parts thus treated, making them more prominent than those that are simply polished. After burnishing, the article is passed through a cyanide wash and cleaned in hot water. A gold-plated article should never be lacquered, as it robs the color of the plating of its beauty.

100. Lacquering.—After plating, polishing, and burnishing, the fittings of the fixture are consigned to the lacquering department, where they are carefully wiped so as to remove all dust, grime, etc. They are then placed in a steam-heated closet, and when thoroughly heated, the lacquer is applied. By having the fittings hot, the lacquer distributes itself equally over all parts of the material treated. After the lacquer is applied, the fittings are placed in the steam closet to dry.

The lacquer used for brass or bronze fittings is composed of alcohol, shellac, and seed lac, the latter ingredient being

used to harden the mixture when applied. Lacquering an article serves to keep it from tarnishing.

101. Assembling Fixtures.—The different fittings are next taken to the fitting department, where they are joined together, and iron pipes for the gasway are supplied where necessary. Before the different parts of a fixture are finally fitted together, however, great care must be taken to ascertain that the arms and light connections, stems, arm tubing, bodies, etc., are perfect in every respect, especially proof against leakage. A thorough test must also be made of all arms and connections before attaching them to the body of the fixture, and much time and labor for some future day may thus be saved. After a fixture is completed, it is sometimes very difficult to determine the exact location of a fault, if any exists.

In preparing an electric arm, a small ball chain connected to a steel wire is passed through the tubing, in order to locate any brazing solder or other foreign substance that may be inside of it, after which the electric wires are fastened to the steel wire and pulled through.

The ball chain is used for bent arms as it can be worked through the tubing more readily than the steel wire. The steel wire, however, is used in places where it can be pulled through easily; as, for instance, in arms with a difficult bend that have openings at certain points to allow the fitting or fittings to be brazed to the tubing.

When the electric wires have been pulled through the arms, they are connected with the main, or stem, wire by soldering each connection, after which they are tightly bound with rubber and cloth tape to prevent short-circuiting. Soldering, however, must never be omitted.

In combination arms, the compartment reserved for electricity is wired in the manner just described.

102. The gas compartments in combination arms and gas arms are tested in the following manner: One end of the tubing is closed with the palm of the hand or the thumb and the air is withdrawn from the tubing. The tongue is

then applied, and if it adheres to the opening by force of the vacuum created, the tubing is gas-tight; if the tongue gradually slips away and the tubing will not adhere to it, it must be taken to indicate that there is a leak somewhere.

The exact location of the defect may be determined by plunging the gas arm into water and then blowing through the tubing; any point in the arm from which air bubbles emanate will indicate the exact location of the leak.

After being tested and joined together, the fixture at last passes into the shipping department where the necessary supplies, such as glass, candles, burner, etc., are provided. The fixture is then complete and ready to be installed.

USE AND DESIGN OF LIGHTING FIXTURES

USE OF LIGHTING FIXTURES

ADAPTATION TO INDOOR LIGHTING

INTRODUCTION

1. Fixtures for Public and Private Buildings. There is an appreciable difference between the fixtures intended for public buildings and those intended for private dwellings, and this difference consists largely in scale or relative dimensions. As the halls, corridors, and various rooms of public buildings are ordinarily much larger than those of private residences, the fixtures should be larger and more substantial in construction. A large room requires a fixture of much larger spread and heavier construction than a small room; in fact, such a fixture would appear out of scale if placed in a small room. The demand for heavier and larger fixtures for large rooms is due principally to the comparatively high ceilings, which necessitate placing the fixtures at a greater distance from the eye of the observer than would be possible in dwellings. Therefore, in designing chandeliers, brackets, and other fixtures, the fixture designer should always take the size of the room into consideration.

2. Style of Fixtures.—The relative size or scale of the fixture having been decided on, the next and very important matter of style must be determined. In the more expensive residences and in public buildings designed by skilful architects, each room is often designed in a separate style of architectural treatment, or all rooms are treated in the same style as the building itself. The former plan is quite likely to be adapted for residences, while the latter generally applies to public buildings. In either case, the fixtures must harmonize with the design of the room in which they are to be placed. All fixtures do not necessarily have to be alike, but they should at least always be ornamented in the same style as the room or hallway in which they are located.

3. Combination Lighting.—In many localities, it is a common custom to install **combination fixtures,** or fixtures that provide for illumination by gas and electricity. Fixtures of this kind are very convenient, for in the event of one illuminant failing, the other can be brought into immediate use. However, the failure of either gas or electricity, for even a few hours, is so infrequent where supplied by public corporations that combination lighting may ordinarily be ignored. In most cases, it is quite safe to install either gas or electricity alone, and a considerable amount can then be saved in the price of the fixtures. There are some localities, however, where a constant current of electricity cannot be depended on, in which event it is advisable, for important work, to adopt combination fixtures as a precaution.

4. Lights Required.—The number and position of lights necessary in a room depends on the purpose for which the illumination is intended, and, in private dwellings, the wishes of the client should be carefully considered in this connection. No specific rule for obtaining the candlepower required for lighting can be given, but it varies from 1 candlepower to several for every 40 cubic feet of room space, the color of the walls, ceilings, floors, and decorations having considerable to do with the amount necessary.

FIXTURES FOR VARIOUS PLACES

5. Vestibules.—In the vestibule, or antechamber, between the outer door of a building and the hallway, lanterns, ceiling lights, or brackets, for either gas or electricity, are used. Vestibules of private dwellings are generally equipped with one outlet only, while those of public buildings may have one or more. The ceiling can be fitted with an electric ceiling light, and the wall outlet might be provided with a gas bracket; or, a gas lantern could be used, and an electric bracket be placed on the side wall.

6. Main Halls.—Main halls or passageways are generally fitted with brackets. Where gas and electricity are used, the fixtures should be "combination," so that an emergency light can be provided should either the gas or the electric current fail. This plan is usually required by the authorities for all public buildings. When gas and electric brackets are used separately, the fixtures should be of the same design.

7. Parlors and Reception Rooms.—Parlors and reception rooms are often lighted by means of chandeliers and brackets, and when electricity is to be largely used, probably the best arrangement is a combination chandelier and straight-electric or gas brackets. When gas is to be largely used, the chandelier might be combination and the brackets gas, or vice versa. The use of chandeliers in this connection is gradually dying out, however, and these fixtures are being replaced by standard lamps with art-glass shades, which are placed on center tables.

8. Dining Rooms.—The dining room is usually lighted from wall brackets or a ceiling cluster, combined with a pendant lamp; or a gas or electric table lamp to light the table top is commonly used. When the gas is for constant use and the electricity for emergency only, a gas table lamp should be provided, and vice versa if electricity is used. When electric table lamps are used, the wires are run through the table top to the floor, or a wire is connected to a socket placed in the ceiling directly above.

9. Libraries.—The lights appropriate for the library include chandeliers, brackets, table lamps, and standards. The center light may be either a chandelier or a table lamp. The former is probably the better under ordinary circumstances, for with proper shades the light may be thrown on the book of a reader at the most suitable angle. The average table lamp throws most of its light on the table top instead of on the book in the hand of a reader; it is much more artistic, however, and, if the shade is properly formed, will do very well for the average reader.

The other standards used for library lighting are usually connected by a flexible cord to outlets located over bookcases or in the walls near the proposed position of the reading table on which the standard is placed. A standard may be used as a reading lamp, a general illuminant, or to light up the backs of the books on the shelves, the flexible cord permitting the lamp to be placed in nearly any position. The construction of these standards should be straight electric or gas, or gas and electric alternately, if there are a number of them in the same room. The brackets may be combination, straight gas, or electric, as the occasion may demand.

10. Dens.—Soft and subdued light is usually the rule for a den. A table lamp having a shade rich in design and deep in color, or possibly a ceiling light with a dish shade made of ground glass, might be used. Brackets, also, with light-subduing shades are appropriate. This room, however, is a place where the personality of the occupant should have full sway; therefore, what might be done can only be suggested here. The person concerned, knowing the limitations, should dictate the methods and conditions of lighting.

11. Bed Chambers.—Brackets, either combination, straight electric, or gas, are the usual fixtures for bedrooms, although the reading lamp with flexible-cord connection is often included.

12. Card Rooms.—Card rooms are provided with pendant fixtures, which are placed over each table. To become a

prominent feature in the decoration of the room, these fixtures may be of simple design or may be elaborated with beaded or silk fringe, leaded glass, etc.

13. Billiard Rooms.—When gas is used in the billiard room, the fixture usually consists of a straight-arm chandelier having a spread of 24 inches at right angles to and 48 inches parallel with the length of the table. At least a few of these fixtures should be supplied with reflectors, which are placed over the groups of light at the ends of the arms. When electricity is used, the same type of fixture is suitable, the lights being collected in groups of three at the ends of the arms and intermediate points and covered with reflectors.

14. Miscellaneous Rooms.—As a rule, kitchens, laundries, vaults, attics, and similar rooms are lighted by the cheapest types of fixtures.

15. Porches.—Porches and porte cochères are usually lighted by electric ceiling lights that are covered with a ground-glass dish or globe; or, they may be lighted by gas or electric lanterns.

SWITCHES

16. Switches, which are devices for controlling the lights, are usually employed in places where the keys of the various electric and combination fixtures are so located that they are not easily accessible. In the more expensive work, even the keys that can be reached without difficulty, such as brackets, are controlled in this manner.

As a rule, switches are used in the following locations:

1. To control the porch and vestibule lamps.

2. To control the lights in stair halls and stairways. A very desirable arrangement is to connect all stair-hall and stairway lights to switches placed on the first floor, so that the lights can be turned on before ascending the stairway, and also on the upper floors, so that on retiring all hall lights can be extinguished. The latter arrangement can be utilized for lighting up the halls before descending should

the occupants of the bedrooms desire to go downstairs during the night.

3. Cellar stairways and cellars should be controlled by switches.

4. Each room should have an independent switch, so that all lights may be turned on or extinguished at will. Where the rooms are large, double switches are used, so that the lighting system is divided into two sections. By this arrangement, one-half of the light may be used if desired.

5. Switches should be located near the doorways, so that they can be easily reached and controlled on entering a room.

LOCATION OF LIGHTING FIXTURES

17. General Location.—The chief considerations governing the location of lighting fixtures are that they shall light the rooms to good advantage, and that they shall cause no danger from fire.

Chandeliers should be hung from as near the center of the ceiling as practicable, and if several side lights are used in the same room, they should be placed at the same height from the floor.

Swing gas brackets should not be used for lighting hallways, stairs, vestibules, or other passageways, for there is always a possibility of swinging the light too close to the wall and allowing it to remain there unnoticed until, perhaps, the building is set on fire. Swing gas brackets are always a source of danger when located within reach of woodwork or drapery, and are therefore not to be recommended for general use. In most cases it is preferable to use two single lights on stiff brackets instead, or a bracket having two or more rigid arms with fixed lights may be employed.

Care should be taken to locate the side lights so that wooden doors cannot be swung back against them and break the shades and globes, or possibly be scorched or set on fire. Lights should not be placed where they may be put out by strong drafts of air or by the sudden slamming of a door

for a gas burner extinguished with a full head of gas on is very dangerous, and may cause loss of life by either asphyxiation or explosion. Hot-air registers in floors or walls should be carefully avoided in locating gas fixtures, for when placed over or near a register, the light will flicker incessantly and will be a source of great annoyance.

18. Bedrooms.—For lighting bedrooms the fixtures should be located so that the bed, wardrobe, dressing case, mirror, etc. may be placed in desirable positions without interfering with the light. The positions of the closets should be noted, and, if practicable, the light should be arranged to shine into them, so that the contents may be easily seen. Where electricity is used, a light placed at the ceiling and controlled either by a wall or a door switch is very desirable. Dressing mirrors should be provided with two stiff-bracket lights, one on each side, and in order to illuminate the head and shoulders of the person using the mirror, properly, these lights should be placed as high as they can be conveniently reached. In some cases a small ceiling fixture is placed adjacent to the mirror, the light shining over the head of the person in front of it.

19. Bathrooms and Closets.—In bathrooms the lights should be set high, so that a person will not strike them in taking off or putting on clothing. A light should not be located over a bathtub or a wash bowl, nor very near them, because of the liability of accident.

A gas fixture should never be placed in a closet or other very small room, if there is any danger of the door being closed and the light left burning. If that should happen, the temperature would rise rapidly and any combustible material in the room might become ignited.

20. Kitchens and Laundries. A kitchen or laundry should be lighted by pendants whenever practicable. If side lights must be used, they should not be placed over the sink nor near enough to it to be struck or be splashed with water. The best place for a side light is usually over the pastry table. A side light should not be placed over a set of tubs

if it can be avoided; a better place is at the head of the ironing table

21. Stairways and Hallways.—Stairways should be provided with a light both at the top and at the bottom. A light on a newel post alone is not sufficient to illuminate the steps properly. Persons with defective eyesight are especially liable to accident on stairways, and the light should be arranged so as to avoid all shadows that might prove deceptive. The stairway leading from the kitchen to the basement, or cellar, should be lighted by a burner located some distance away from the foot of the stairs. If the light is near the foot of the stairs, there is danger of it being struck when large articles are carried past.

Hallways are best lighted by a pendant; if a side light is used, it should be placed where it will not interfere with the coat rack, mirror, or other hall furniture. A pendant in a hallway or vestibule should be set so high that the globes cannot be knocked off by a person putting on an overcoat.

22. Height of Fixtures.—The proper height above the floor for lights depends somewhat on circumstances. In ordinary dwellings having ceilings 9 feet or more in height, side lights should be placed from 5½ to 6 feet high, while pendants may be hung from 6½ to 7 feet from the floor. If the rooms are large and high, the lights of chandeliers may be placed at a height of 7 to 8 feet, or even more. Side lights in hallways and vestibules of churches and similar buildings should be placed at a height of at least 7 feet. Low lights should be avoided, because they are tiresome to the eyes; if they must be used, they should be provided with opaque shades.

DESIGN OF FIXTURES

ENRICHMENT OF LIGHTING FIXTURES

ORNAMENTATION OF VARIOUS PERIODS

23. Introduction.—The lighting fixtures for the best work are designed to harmonize with the style of architecture of the building or room in which they are to be placed. Manufacturers usually carry the best-known styles of fixtures in stock, and also have in their employ designers that are capable of preparing any designs wanted. The text and illustrations that follow are intended to be only a brief résumé of each style of lighting fixture, and if it is desired to incorporate any particular ornament in designing a fixture, the example of that style should be carefully studied in order to master all the details involved.

Near the end of this Section will be found a series of plates illustrating the typical treatment of ornament characteristic of the principal schools of design. A careful study and an analytic comparison of these ornamental motifs will be of invaluable service, and will not only enable the textual descriptions to be better understood, but will so cultivate the eye that the school of ornament to which each feature belongs may be readily discerned.

24. Prehistoric Ornament.—The art of decorating or ornamenting objects can be traced back as far as history. The caves of Western Europe and the mounds and excavations in America reveal that this esthetic desire was possessed and very cleverly gratified by even prehistoric peoples.

Besides animal forms, the motifs employed were the swastika, dots, zigzags or chevrons, circles, scrolls, and other rudimentary forms. The basket pattern so often used

originated probably in the manufacture of boiling pots from willows and clay; these pots when broken exposed the impressions made by the wickerwork.

Reference to Plate I will serve to illustrate some of the characteristic features of primeval decoration, as executed by man in his savage state. Such decoration was produced on clay products, as bowls and vases, and also in rock markings. Even in their crudeness, they exhibit the innate desire of mankind to beautify and make pleasing to the eye the simplest utensils of every-day use. The zigzag expressed in their work furnished the decorative element that was afterwards amplified and made so typical of the Norman school of Gothic design, as shown in the chevron in Plate IX.

Even the effect of the dots in their diaper work is presented in the finished Greek school in the grouping of the guttæ, or drops, in the mutules on the soffit of the cornice of the Doric order. The *fylot*, or four-footed Greek cross, also called the *swastika*, is very ancient, and is found among savage peoples of widely separated origin and locality, and while considered by some to have had some religious symbolism, its original import is unknown. In some form or other, its elementary character was observed in Phenician, Arabian, Hindu, Scandinavian, and British ornament. In recent times, the swastika has again become popular, principally in articles of personal adornment. The Indian animal forms from rock carvings are suggestive of the Egyptian hieroglyphs (sacred writings), such picture symbolism implying not particularly the animal itself, but its character, as the picture of the fox would indicate craft and cunning. The Chinese, Aztecs, ancient Peruvians, and the Indian tribes of North America thus expressed themselves in this form of written language.

25. **Egyptian Ornament.**—The reign of Rameses I—from about 1400 to 1366 B. C.—witnessed probably the highest development of Egyptian art, that which followed and persisted through the years of foreign domination showing evident signs of decadence. In spite of the fact

that most of the decoration remaining today is of this decadent period, it is in some respects unexcelled by any subsequent style.

In conventionalizing the lotus, the beetle, the hawk, the cobra, etc., and in figure work in intaglio, the Egyptians leave little to be desired. Directly conventionalized, the lotus flower is the most prominent feature of Egyptian art, and there is little doubt that this flower inspired the spiral-scroll, anthemion, egg-and-dart, and rosette ornaments found later in Assyrian and Greek art. The lotus is a species of water lily, and was recognized by the Egyptians as the emblem of future life and the resurrection.

Other motifs employed by the Egyptians were fan-shaped feather designs, signifying sovereignty; the zigzag, fret, whorl, scales, star, etc.; also, animal forms, or adaptations of animal forms, such as the sphinx, bull, lion, deer, ibex, gazelle, swan, scarab (sacred beetle), fish, and creatures having the head of a vulture and the body of a lion. These forms were principally used as surface ornament, being colored in flat tints without shade or shadow.

The Egyptians not only believed in a trinity—Isis, her spouse Osiris, and Horus their son—but also in several other deities. These, with their attributes and emblems, figure prominently in Egyptian decoration and furnish a rich and inspiring list of motifs. The goddess Isis is represented by a female figure, on whose head rests the solar disk (an emblem of God), cow's horns, and sometimes a miniature throne; she also bears a lotus scepter in her hand. Osiris is represented by a mummy wearing a crown, which is a bottle-shaped object flanked by two flat shapes, with ogee outlines representing conventionalized ostrich plumes. Horus is represented by a hawk-headed man.

Thus, it can readily be seen that the Egyptian designers were very generously supplied with motifs for their ornament, and even a cursory examination of copies of their work will show how well they improved their opportunities. Their work was principally in intaglio and polychrome surface ornament and combinations of these two.

Plate II shows the more prominent motifs of decoration used by the Egyptian artist in ornamenting his creations, whether in stone or metal.

26. Figs. 1 and 2 show fixtures designed in the Egyptian style of ornamentation. In Fig. 1 is shown a wall bracket having the wall panel, or back, ornamented with a winged cobra, out of which the stems grow that support the electric candles. The husk and sockets are expressed in conventionalized lotus leaves and buds, respectively. Fig. 2 illustrates a ceiling pendant in bronze and glass. The ceiling shell is treated as a lotus bulb, and the tips of the arms supporting the shade are masked with papyrus bulbs. The upper and lower metal portions of the frame are modeled as winged cobras and winged disks. Opalescent glass is used for the panels, thus softening the light and obscuring the glare of the electric lamps concealed in the body of the frame. Directness, simplicity, and severity are well expressed in these figures and suggest an atmosphere of symbolism and mysticism peculiar to all Egyptian work.

27. Grecian Ornament.—Greek art was at its best from about 480 to about 323 B. C., although it lasted until about 100 B. C. It is characterized by beauty and refinement of outline and great reserve and dignity. Although preserved in imperfect form, the work of the Greeks has served as an inspiration to artists even to this day, and direct adaptations of their three architectural orders (see Plate III) are to be seen everywhere. The motifs used by the Greeks in their ornament are the acanthus, egg and dart, anthemion, water leaf, palm, bay, laurel, ivy, rosette, and meander. Of all these, the egg and dart, anthemion, water leaf, palm, and rosette, and also the Ionic capital, are undoubtedly derived from the Egyptian lotus, through the intercourse of the Greeks themselves with the Egyptians and through the Assyrians, who derived much from the Egyptians.

An element of beauty in connection with Greek ornament is the relative proportioning of the ornament and its background, and the method of conventionalizing and

proportioning growth. The evolution of the Greek ornament motifs from the lotus motif of the Egyptian is readily seen when the several steps are traced. The Greeks, however, undoubtedly first used the acanthus leaf, a motif that subsequent designers have not been able to improve upon. This is properly supposed to be the conventionalized leaf of a herbaceous plant called the *acanthus*.

Not until late in the 19th century was it known that the Greeks colored their buildings and ornaments. Could these works be seen in their original vivid colorings, it is doubtful whether they would be enjoyed so much as at present, that is, with their appearance conceived as being restored without color. The Greek ornament in color now extant is found principally on vases. Carved ornament was used on vases, moldings, and other surfaces.

Fig. 3 illustrates a fixture designed in the style of Grecian ornament.

28. Roman Ornament.—From about 100 B. C., to about 100 A. D., Roman art flourished. Without doubt the Romans received their inspirations from the Greeks, as nearly all of their principal motifs are easily traceable to that source. The characteristics of the Roman people may in this case—as is invariably true in art—be read from their work. They were a world-conquering power, and therefore wealthy at the time their art was flourishing; and being prosperous, warlike, vigorous, and impetuous, they loved lavish and somewhat barbarous display. It is therefore not surprising that their ornament is profuse, rich, and somewhat garish, which latter tendency was held in check and refined by their Greek artists.

Roman ornament has less background than Greek ornament, and the motifs are more intricate and less delicate and subtle in outline. The motifs used in Roman ornament (see Plate IV) include the anthemion, the acanthus, garlands and swags of fruits and flowers, rosettes, griffins, fauns, satyrs, frets, keys, and meanders.

Fig. 4 illustrates a standard designed in the Roman style, the principal element in the treatment being foliated bands of the graceful acanthus grouped in stages around the shaft supporting the globe.

29. Pompeian Ornament.—The city of Pompeii was destroyed by the eruption of Vesuvius in 79 A. D., and was rediscovered in 1748. The ornament of Pompeii was undoubtedly inspired by that of the Romans and the Greeks, but it forsakes the conservatism of the Greek work, being full of vivacity and possessing all the richness and grace of the Roman work, without its heaviness (see Plate V). Pompeian frescos are noted, and are characterized by grace and lightness of the forms, which are often representations of courts, rooms, bowers, etc. in perspective. Cupids, heroes, nymphs, masks, etc. were also used freely and gracefully. Strong colors were used in these frescos, except where a many-colored scheme was employed, in which case the colors were in pale tints. Although the color schemes are usually delightful, occasionally they are crude and not pleasing.

In modeled ornament, the Pompeian shows a strong individuality, with indications of a sure hand and an inborn knowledge of what is beautiful. He applied his ornament to objects of every-day use, such as chairs, tables, lamps, vases, braziers, etc.

The motifs, as stated, are largely derived from the Romans and the Greeks, and among them are found the acanthus, the anthemion, the scroll, the egg and dart, garlands, festoons, griffins, fauns, satyrs, etc. The human figure was also used considerably in statuettes, as supports for braziers, tables, lamps, etc., and was modeled with great cleverness and beauty.

A three-light standard, or candelabrum, designed in the Pompeian style, is shown in Fig. 5.

30. Byzantine Ornament.—Byzantine ornament had its beginning in the building of the new capital of the Roman Empire at Byzantium, now Constantinople, in the

year 330 A. D., and may be said to have lasted until the fall of the city, in 1453 A. D. This style includes not only the work done at Byzantium, but that done under its influence at Ravenna, Venice, and elsewhere.

The school of ornament is the result of the fusion of the Roman, Greek, and Romanesque art influences with those of Persia and Assyria. The resultant is a splendid style of design to which the name *Byzantine* has been given (see Plate VI). The influence of this style may be seen all over Europe in Romanesque and Renaissance work, and also in work that may be considered strictly Byzantine. The style employed by the Russians at the present time may be considered as a survival of the old Byzantine.

Byzantine ornament is characterized by richness and splendor. Gold, or positive, color was used as a background for intricate arabesques, which were of conventionalized acanthus, etc., or geometrical ornament, the background being reduced to a minimum. Their outlines were somewhat crude and stiff, but taken as a whole, the ornament is rich and very effective in the best examples. In many instances, jewels, surrounded by twisted stems of acanthus, etc., were used as bosses or studs. Among the motifs employed, the more prominent are the acanthus, the rosette, the palmette, or a greatly conventionalized anthemion. The circle, the cross, and human, animal, and bird forms are also used.

Fig. 6 illustrates a fixture designed in the Byzantine style.

31. Romanesque Ornament.—The Romanesque style, largely developed under the instruction of the monastic orders, lasted from about 1000 to 1150 A. D., and followed the Early Christian style. This sober and dignified ornament is based on Romano-Byzantine and classic work, and its distinctive features can be more easily recognized than described. The acanthus was represented with sharp-pointed serrations and prominent and vigorous stems, and this and other growths show a tendency toward concavity of form.

As a rule, Romanesque ornament is simple in motif and arrangement, which is no doubt due to economy. It is heavy and coarse in general effect, but, except in some of the late examples, is rarely ungraceful (see Plate VII). Animal forms were frequently used—some very realistic, others strictly conventional and sometimes very grotesque.

In brief, the Romanesque style reflects the characteristics of the people of the middle ages—coarse, vigorous, and bold. Among the motifs encountered in an examination of Romanesque ornament are the acanthus, the spiral, the rosette, strapwork, and animal forms.

Fig. 7 illustrates a fixture designed in the Romanesque style.

32. Saracenic Ornament.—Saracenic art—from approximately 350 to 1600 A. D.—covers the work done under the Moorish conquerors of Spain, under the Turks, Arabians, Persians, and East Indians, and under the Egyptains in Cairo. This art is strictly Mohammedan, and the religion of this prophet determined its character.

Owen Jones, in his "Grammar of Ornament," says that "Construction should be decorated; decoration should never be purposely constructed." It would seem, therefore, that Saracenic ornament should be condemned in this respect, for in its use on buildings, it is largely placed without logical reference to the construction. In spite of this fact, however, the Moorish mosques, especially the interiors, are often very beautiful.

The Moors were very proficient in the carving of ivory and stone, the making of jewelry and pottery, stucco modeling, glass blowing, weaving textile fabrics, and other arts. As the Koran forbids the use of animal forms in ornament, the motifs consist chiefly of geometrical and leaf forms, beading, and Arabic letters. Bosses and the interlacing strap are characteristic of all the various divisions of the Saracenic schools of ornament (see Plate VIII).

Figs. 8 and 9 illustrate two pendants, designed and colored in the Saracenic, or Moorish, style.

33. Gothic Ornament.—Gothic ornament may be said to have existed from approximately 1200 to 1450 A. D. The term *Gothic* as generally accepted and applied to the style of this period is a misnomer, and a better term would be the *Christian style*, which might be said to have had its beginning in the Early Christian era, its middle in the Romanesque and Byzantine eras, and its culmination and glory in the Gothic era. The period of time given for the Gothic refers to this latter era. The German, Spanish, and Italian Gothic are inferior to the English and French, in that the ornament of the former is much more realistic and less original, is less logical in construction, and, especially in the Italian work, is a mixture of classic and Gothic.

34. The **English Gothic** is considered the best, and is subdivided i [illegible] *rly*, *Decorated*, and *Perpendicular*.

The **Early En** [illegible] bably the best of the three periods, ar [illegible] propriately designed. The leafwork is [illegible] lines and prominent stems, as in the [illegible] sually fills the space well with main lines appropriate to the form decorated. The motifs are splendidly conventionalized, and the starting points of growth are usually cleverly placed.

The ornament of the **Middle**, or **Decorated, period** is less conventional and not always quite so logical in application. The characteristic lines of the ornament of this period might be said to be undulating, or wave-like.

The **Perpendicular period ornament** was still more realistic, and evidences of a decline are apparent. The leaf forms are more rectangular than in the previous period (see Plate IX).

35. The **French Gothic periods** are the *Early*, the *Rayonnant*, and the *Flamboyant*, and the ornament of these periods possesses characteristics similar to those of the contemporary English periods. **Rayonnant** means "radiating," and refers to a characteristic of the ornament, tracery, etc. of this period. **Flamboyant** means "flaming," and refers

to the characteristic lines of tracery, leaf forms, etc. of this period, which precedes the Renaissance.

Characteristic motifs of the style of the French Gothic periods (see Plate X) include the quatrefoil, the trefoil, and the cinquefoil, the leaf forms, especially in the early periods, possessing a certain convexity of shape not found in any other style. Moldings were deep cut, and the bird's beak and the reed are much in evidence. The moldings were also ornamented with the dog-tooth, leaved flower bosses, ball flowers, cornice flowers, grape vines, crockets, etc.

Fig. 10 illustrates a fixture designed in the style of the French Gothic period.

36. Renaissance Ornament.—The Renaissance style of art and architecture probably owed its inception to the revival of classic litera ... 14th and 15th centuries, which was f ... by the invention of printing, in 1431. F ... ement spread to France, Germany, and ... e that formerly was included in the Ro ... ntinued until the 18th century.

This revival of the classic shows the greatest purity in Italy, where the Gothic had never entirely replaced it. For this reason the classic lacks a certain charm, which the French Renaissance possesses in a marked degree, and which is due to the infusion of a certain amount of Gothic influence. In England, the Gothic feeling was more tenacious, and is never entirely missing from the Renaissance work.

The German Renaissance partakes of the general characteristics of the French, but is much less refined. It also has some of the characteristics of the late English Renaissance. The Spanish Renaissance shows both Gothic and Moorish influence, and in the early work is very beautiful.

37. Italian Renaissance.—The source of the Renaissance movement throughout Europe from 1400 to 1600 A. D. was the revival of learning and classic art in Italy. The writings of Boccaccio, Petrarch, and Dante had much to do

Fig. 1

159 FIG 3 143

Fig. 4

159 Fig. 5 δ 43

169

Fig 6

ϕ 43

159 FIG. 7 § 43

FIG. 8

with the new interest in literature, which was greatly assisted by the invention of printing.

The motifs employed were those of the Roman and Greek with a reminiscence here and there of the Romanesque or Byzantine (see Plate XI). They include the acanthus, the encarpus, nymphs, cupids, griffins, masks, vases, ribbons, spirals, etc. The Italian Renaissance is an exuberant style, full of vivacity and sentiment, and displays a wonderful inventive and creative faculty, backed by great enthusiasm and strength.

Figs. 11, 12, 13, 14, 15, 16, 17, and 18, which illustrate fixtures designed in this style, will serve to show its scope of treatment, effectiveness, and consequent popularity.

38. French Renaissance.—The French Renaissance ornament, which is considered the most clever and original of the Renaissance styles, cannot be properly described in a few words. The examples of ornament usually illustrated are taken from the work executed for the different kings by foreign and native artists, but a vast amount of very superior work was also done by craftsmen outside of the court influence, which, however, does not bear the distinctive marks of the different courts (see Plate XII). For this reason, it is difficult to locate this ornament chronologically without an intimate knowledge of French art and literature.

The work done under the influence of the various courts may be separated into periods, which include the reigns of several rulers, as follows:

Period	Name of Ruler	Duration of Reign
Early Renaissance, or Valois	Louis XI	1461–1483
	Charles VIII	1483–1498
	Louis XII	1498–1515
	Francis I	1515–1547
	Henry II	1547–1559
	Francis II	1559–1560
	Charles IX	1560–1574
	Henry III	1574–1589

Period	Name of Ruler	Duration of Reign
Bourbon	Henry IV	1589–1610
	Louis XIII	1610–1643
	Louis XIV	1643–1715
Rococo	Louis XV	1715–1774
	Louis XVI	1774–1793
Empire	Napoleon I	1804–1814

39. Valois Period.—The work under the Early Renaissance, or Valois, period is probably best illustrated by the work done during the reigns of Francis I and Henry II (see Plate XIII). Characteristic of the ornament of the style under Francis I are paneled pilasters intersected by diamond or rosette patterns, carved tracery, the salamander (the symbol of Francis I), cherubs, heads, the human figure, satyrs, griffins, **S** consoles, medallions, cartouches, the rope (symbol of Anne of Brittany, wife of Louis XII), the conventionalized ermine symbol, etc.

A ceiling pendant constructed of alabaster, suspended with gold-plated chains, and designed after the style of Francis I, is shown in Fig. 19. In this fixture, the whole font glows with light from the interior lamps.

The work under Henry II, son of Francis I, probably reached the highest plane of the French Renaissance. The ornament is admirable in composition and proportion and somewhat more formal and sober than that under Francis I. Figs. 20 and 21 are photographic reproductions of a ceiling fixture of this time from the palace of Fontainebleau.

The motifs include the cartouch, the grotesque mask, fruits, trophies, weapons, ribbons, and the male and female torso; the crescent, a symbol of Diana of Poitiers, who was the mistress of Henry II, and the intertwined initials H and D are characteristic of this period.

The ornament under Henry III does not differ materially from that under his father, Henry II, except that it is somewhat heavier and not quite so refined and graceful.

Fig. 22 illustrates a modern fixture designed in the style of Henry II.

40. Bourbon Period.—The Bourbon period begins with Henry of Navarre, or Henry IV, and here, as in the previous period, is found the grotesque head, fruits, ribbons, and cartouches (see Plate XIV). The human torso and the mask do not find such general use, but the human figure is used freely and in a realistic manner—filling the niche, being seated amid the arabesque, or lying in the panel. The classic garland and the encarpus also appear frequently in the ornament of this period.

Fig. 23 illustrates a fixture designed in the style of Henry IV.

41. Upon comparing the ornament of the Bourbon period under Louis XIII, with that under Henry of Navarre, it will be discovered, first, that paneling has attained prominence, often assuming the form of cartouches centered with a mask or grotesque head. The ribbons, cartouches, etc., now have flamboyant outlines, and the general effect is larger in scale than the ornament under Henry IV. Broken pediments filled with cartouches are used, but have become more popular in later years.

The motifs employed include cartouches, fruits, pendants, war accouterments, cupids, encarpi, and masks. The cartouch is of a very liberal size, and at times grotesquely formed. The rims of the fruit pendants are provided with curling tendrils of bulky proportions, which sometimes assume representation of grotesque human features. Consoles with the broken curves were used, with acanthus leaves on the face.

A very rich, foliated, and floriated design is shown in Fig. 24, which is a photographic reproduction of a ceiling fixture of the time of Louis XIII, from the Palace of Fontainebleau.

42. The ornament of the Bourbon period under Louis XIV, which precedes the Rococo, shows indications of the coming lack of restraint and flamboyant qualities that were spoken of as occasionally appearing during the reign of Louis XIII in the outline of cartouches, etc. Outlines are

not so definite nor so well studied as heretofore, and although rich and full of charm, this tendency toward degeneracy is plainly to be seen (see Plate XV). The ornament under Francis I and Henry II is just as rich and lavish as that under Louis XIV, but it possesses the qualities of restraint and dignity that the ornament under this oppressive monarch, who liked to be called "le grand monarque," largely lacks.

These remarks must not be understood as suggesting that the ornament of this period lacks charm or merit, for much of it is indeed very beautiful. Some of the shell and panel decorations and the capitals of columns are very original and pleasing. Shell forms are characteristic of this and the Rococo period, and latticed backgrounds, grotesque masks, griffins, satyrs, strapwork, encarpi, birds, and the human figure are among the motifs found during this period.

Fig. 25 illustrates a fixture designed in the style of Louis XIV.

43. Rococo Period.—The tendencies displayed in the previous style found their culmination in the *Rococo*, which is the name given to the style in the time of Louis XV. As the reign of this king was without restraint, so the art displays a gaiety, abandon, and lack of logic that, despite qualities of cleverness and grace, displease and annoy (see Plate XVI). It precludes any one from enjoying this ornament except as a novelty, for there are characteristics that forbid long-continued companionship with pleasure.

The flamboyant quality is very noticeable in the lines of cartouches and panelings. The distinguishing features of the Rococo style are the reversed curve, eccentrically shaped paneling, cartouch and shell motifs, and a dashing, swinging, wave-like quality to all the ornament that cannot be found in any other style of French work.

The term *rococo* is used attributively by the French as applying not only to the art of this period, but in contempt of anything in art that is weakly pretentious, gaudy, or lacking in good taste.

Figs. 26, 27, and 28 illustrate fixtures designed in the style of the Rococo period.

44. While the style of ornament during the reign of Louis XVI has been classed with Rococo simply as a matter of convenience in arrangement, it has no resemblance to Rococo ornament, and shows a decided reaction toward the classic and Italian schools. In fact, there is a little Renaissance within the Renaissance, a reformation that culminated in the Empire period under Napoleon Bonaparte, in which the citizens even adopted a classic dress.

The motifs used in the ornament under Louis XVI include garlands of fruits and flowers, pine-cone finials, palms, griffins, cherubs, vases, and other Roman examples. The borders of panels, etc. are a great contrast to those of the Rococo period, being in straight lines, which are only broken rectangularly. For molding and band decoration, the pearl, the fret, and the guilloche are resorted to (see Plate XVII).

Figs. 29, 30, 31, 32, and 33 illustrate fixtures designed in the style of Louis XVI.

45. Empire Period.—The ornament of the Empire period is a further step in the classic direction (see Plate XVIII). Probably the most distinctive quality of this ornament is the use of the color scheme in connection with modeled ornament, the ornament being light upon a dark ground or vice versa. The furniture in this respect is very striking, the ornament being of gilded bronze or fine brass upon dark wood, stone, or marble. The rosette, wreath, olive branch, fleur-de-lis, and anthemion appear frequently, and the bee, Napoleon's emblem, was also often used.

Fig. 34 illustrates a fixture designed in the Empire style.

46. Spanish Renaissance.—Spanish Renaissance ornament may be divided into three periods; namely, *Early*, *Classic*, and *Rococo*.

During the **Early period**, the classic influence was largely subservient to Gothic and Moorish tendencies, and the resulting work equals in richness and originality any

other of Europe, not even excepting that of Francis I. The ornament of the Early period is often called *plateresque*, because of its likeness to the work of silversmiths.

During the **Classic period** the classic ornament increased its influence, and the work is not so pleasing as that of the Early period.

The vagaries shown in the **Rococo period** are practically the same as those found in the other styles of the Renaissance when in their decadence (see Plate XIX).

The motifs found in the Spanish Renaissance ornament include medallions, pilasters, columns, and other arabesques of great richness and grace, and shields, armorial bearings, and bracketed capitals. The ironwork of the Spanish Renaissance is unexcelled by any other style or nation.

Fig. 35 illustrates a fixture designed in Spanish Renaissance style.

47. Mission Style.—The **Mission style** is now principally identified with the manufacture of furniture, and is said to have been inspired by the work in the Franciscan mission buildings of Southern California, although many modern buildings are now designed on lines much in sympathy with the old work. The missions were founded by expeditions sent out from Mexico by the Church, but were settled only after sacrificing many lives and after enduring great hardships. Twenty-one missions were established between the years of 1769 and 1823. An inimical government, the Mexican war with the United States, and immigration to the West finally destroyed their power and paternal control over the Indians, and at the present time there are only four or five of these monasteries in a state of preservation. When the missions were at the height of their prosperity, during the first quarter of the 19th century, the Indians were taught agriculture, carpentry, music, smithery, basket weaving, potterymaking, working in leather, silver, and copper, wood carving, illuminating, book binding, etc., and the simple work of these Indians and their padres has been the inspiration for this style,

which, as stated, is principally adapted to furniture and other domestic appurtenances. The general characteristic of this work is simplicity and heaviness of construction (see Plate XX).

Fig. 36 illustrates a fixture designed in the Mission style.

48. German Renaissance.—The ornament of the German Renaissance—from 1500 to 1650—is inferior to that of England or France during the same period. The best work was accomplished during the development of the style that may be divided into *Early*, *Late*, and *Baroque*, or *Rococo*. At its best, the German ornament is characterized by heaviness and crudity, but shows great cleverness in the invention of the grotesque, such as satyrs, masks, griffins, and elves, especially in wrought-iron work and wood carving, in which it excelled (see Plate XXI).

In the use of geometrical figures, armorial bearings, bosses, spirals, paneling, festoons, garlands, etc., their work is similar to the Elizabethan and Flemish and the Renaissance of Henry IV, but it falls short of them all in grace and beauty, especially the Elizabethan, which is the most pleasing ornament of this quaint class.

Fig. 37 illustrates a fixture designed in the German Renaissance style.

49. English Renaissance.—Under the reign in England of Queen Elizabeth (1558 to 1603 A. D.) and extending partly into that of James I, a transition style called the **Elizabethan**—from the preceding Tudor style to the Jacobean and Renaissance of Sir Christopher Wren and Inigo Jones—was developed. This style is never free from the influence of the preceding Gothic, and is sometimes difficult to distinguish from Flemish and German Renaissance of earlier periods. The Elizabethan style died out completely on the death of James I, and has had little following, except in America, where in recent years it has become quite popular for domestic work, to which it is well suited.

A characteristic of this ornament is the cartouch and the interlacing strapwork, with accompanying coats of arms,

tapered pilasters, minute arches and pilasters, grotesques, ribbons, encarpi, etc. The volute and other curves, together with bosses and smaller studs, are much used in this style of ornament. Many of the motifs are not unlike those found in the ornament under Francis I, and frequently the arabesques and interlacing strapwork suggest the Oriental in their richness (see Plate XXII).

The **Jacobean style** followed the Elizabethan, of which it was a development. This style gradually diverged from the Gothic picturesqueness toward the purer English Renaissance as the classic influence increased through the Italian artists that located in England, the English translations of Palladio, and the foreign education of the English architects Wren, Jones, Gibbs, and others (see Plate XXIII). The characteristics of Jacobean ornament are very similar to those of the Elizabethan period, a leaning toward the classic and a certain grossness being probably the only distinctive differences.

Figs. 38 and 39 illustrate fixtures designed in the style of the English Renaissance.

50. American Colonial Ornament.—The **American colonial style**—from 1634 to 1815—is the offspring of the late English Renaissance brought from England to America by the Colonists, and was probably at its best about 1730. As a rule, the designs of this period are of modest pretensions compared with European work. Examples of this period are to be found in New England; Philadelphia, Pennsylvania; and Annapolis, Maryland; besides many other places throughout the Eastern and Southern states.

Among the motifs used are the acanthus, scallop shell, encarpus, rosette, bead and shuttle, dentil, egg and dart, fret, fillet, and others (see Plate XXIV).

Figs. 40, 41, 42, and 43 illustrate fixtures designed in the American colonial style.

51. Chinese and Japanese.—The ornament of the Japanese and Chinese has been studied with delight by the

159 Fig. 10 § 43

Fig. 11

§ 43

Fig. 12

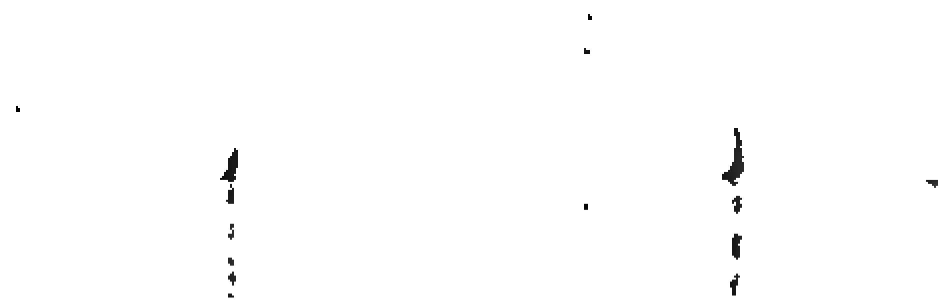
Fig 13

Fig. 14

159 Fig 15 § 43

FIG. 16

150 FIG 17 § 43

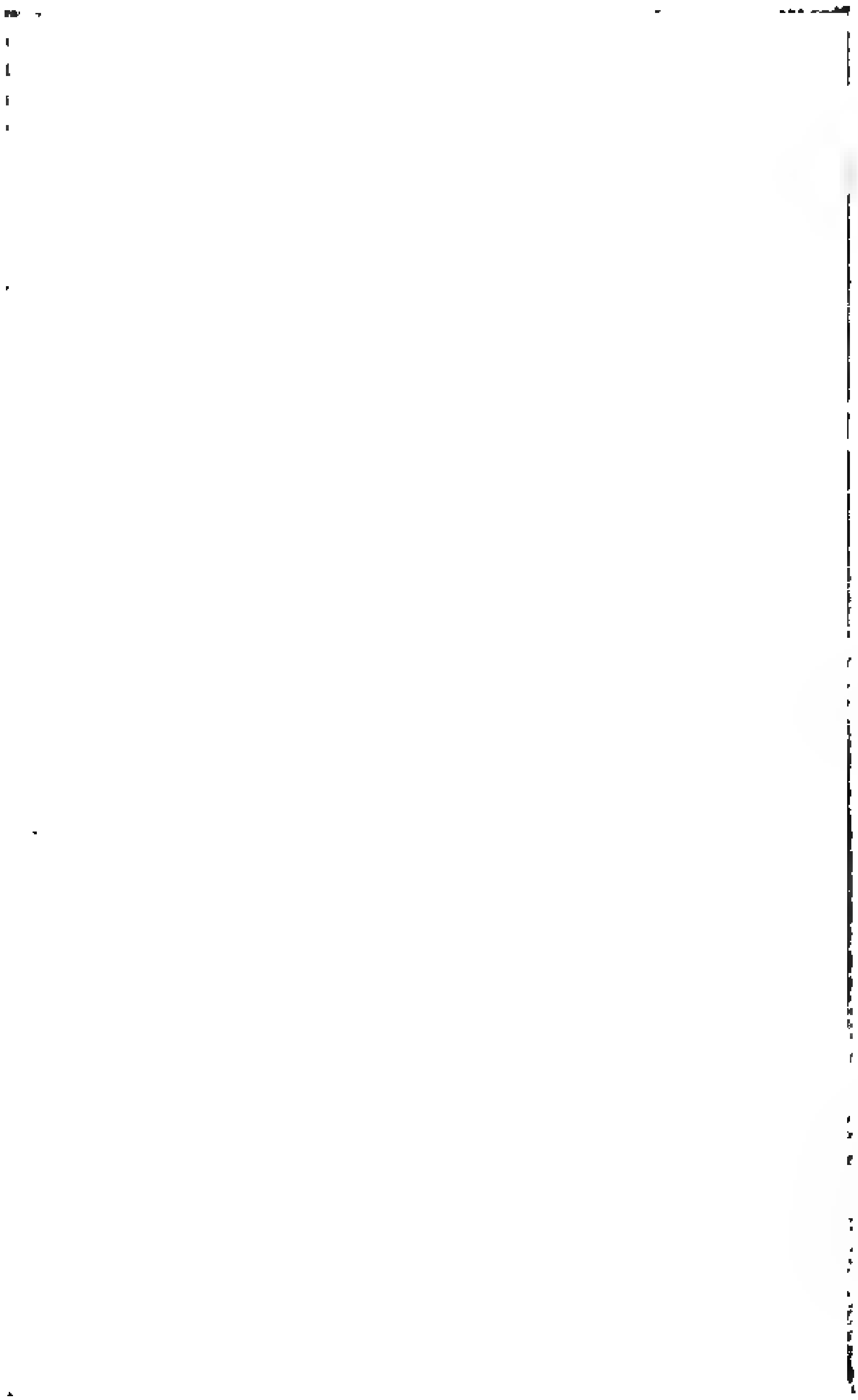


159 Fig. 18 § 43

159 FIG. 19 § 43

FIG. 21

159 Fig. 22 § 43



159 Fig. 25 143

169 FIG. 26 § 43

159 Fig. 27 § 43

159

Fig. 28

§ 43

159 Fig. 29 143

159 Fig 30 160

FIG. 81

 Fig. 32

FIG. 33

§ 43

159 FIG. 34 § 43

159

Fig 35

§ 43

150 FIG. 37 § 43

Fig. 38

FIG. 29

Fig. 40

Fig. 41

159 Fig. 42 § 43

Fig 43

§ 43

modern artist, and although it often seems crude in form, it is generally good in color. Some of the displeasure that arises in examining their ornament may be due to the fact that it is impossible to arrive at the same conclusion as, or even to form a sympathetic opinion for, a people whose history has been so apart from that of the nations known to have furnished more or less motifs and inspirations for the schools of ornament of the present day.

While the ornament of the Chinese may appear odd to the people of other countries, it is not so to them, and the eccentricity of the forms used may possibly be accounted for by their mental makeup. They applied color ornament to buildings in the form of glazed tiles, painted woodwork, and other work of like nature. In the manufacture of silks and cotton fabrics, the Chinese patterns are admirable, and their carvings in wood and ivory show great skill and originality.

While Japanese ornament is similar to that of the Chinese, it has greater refinement and is less conventional. The Japanese designer approaches nature very closely, and there is probably no school of art in existence that draws so generally and liberally from this source for its motifs. Symmetry is often disregarded or cleverly veiled, and motifs are conventionalized just enough to make them very charming. Some of the carved panels to be seen in the temples of Japan are beautiful beyond description.

Among the motifs used in Japanese ornament are found cranes, peacocks, pheasants, ducks, fruits, trees, flowers, lions, demons, and insects (see Plate XXV). Probably the best work of the Japanese designer is found in the carving of wood and ivory, and in pottery and inlaid work.

52. L'Art Nouveau.—As its name implies, **L'Art Nouveau** is *the new art*, that is, a recent development along revolutionary lines, and was probably first apparent during the latter part of the 19th century in Austria and Germany, but is now more or less practiced in Great Britain, France, and America. Up to the present time, this style of

ornament has not shown any strength in architectural design, but in ornament, furniture, and utensils of various kinds some excellent work has been done.

This style is supposed to be founded on natural growth, but much of the ornament is either overrealistic or goes to the opposite extreme, where the motif of inspiration is beyond detection. However, the fact that it is based on the study and conventionalization of plants is conducive to the hope that a virile style may result. Upon considering the designs of this new movement, there seems to be a possibility of ignoring what is good and reasonable in the vocabulary of the old schools of design, instead of accepting these methods and motifs of artistic expression. Upon this foundation, which is a method of expression understood by all through inheritance, is built the new art, being enriched and revived by a study of nature's inexhaustible vocabulary, which after all is the well spring of all art.

A study of the work done by the new school shows that there is at the present time a tendency to long, sweeping lines that dominate the design as well as to a concentration of ornament in strong contrast with plane surfaces. Whatever motifs are used, the idea of root, stem or trunk, and foliage seems to underlie the whole and to be the ruling idea (see Plate XXVI).

Figs. 44 and 45 illustrate fixtures designed in the style of L'Art Nouveau.

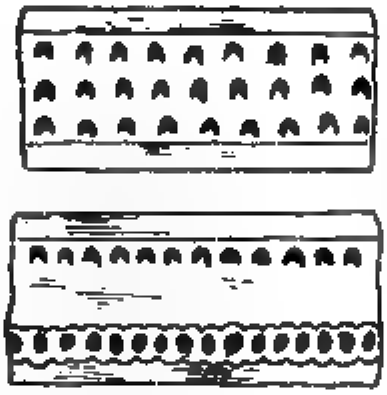
Fig. 44

§ 43

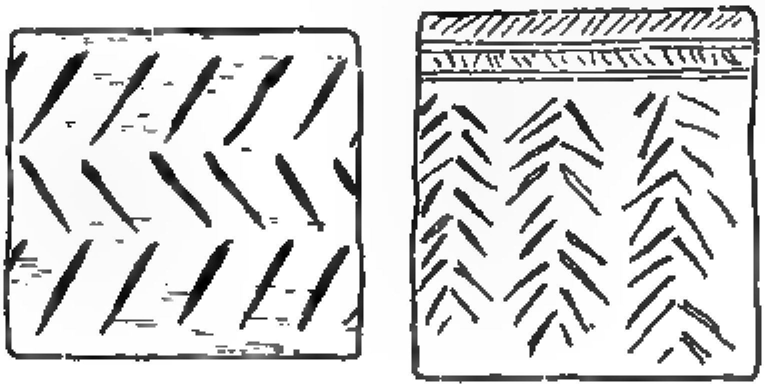
ORNAMENTAL MOTIFS

PREHISTORIC

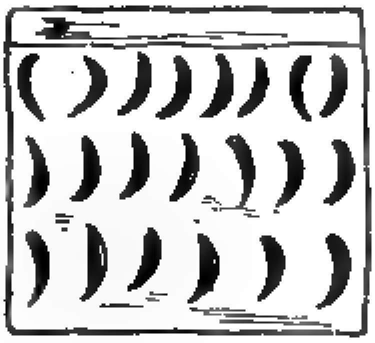
Plate I



GOUGINGS



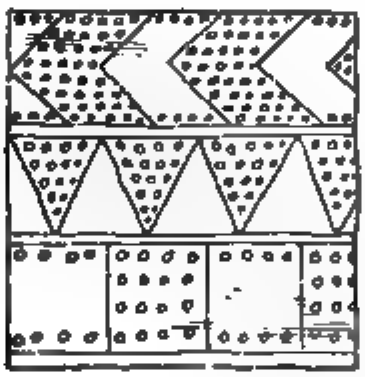
HERRING BONE



FOOTPRINTS

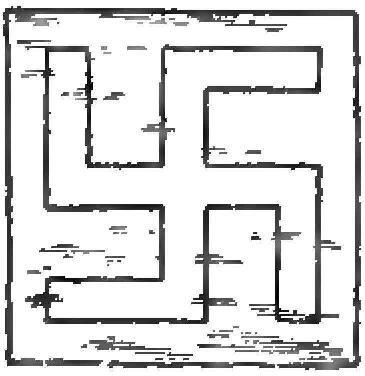
INTERLACING

ZIGZAG



DIAPER WORK

BASKET WEAVE

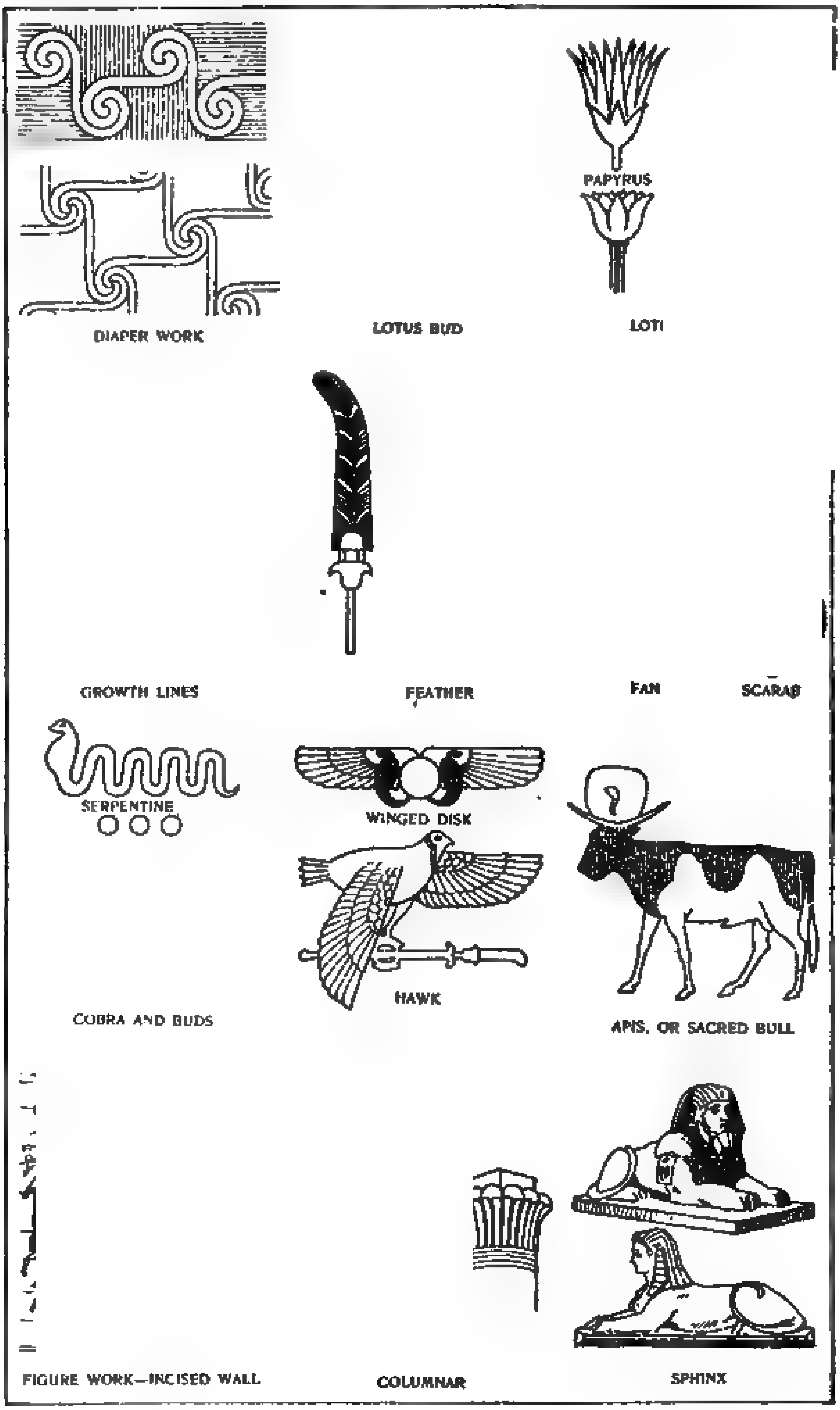


SWASTIKA

ANIMAL FORMS

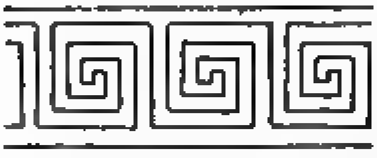
ORNAMENTAL MOTIFS

2100 to 30 B. C. EGYPTIAN Plate II



ORNAMENTAL MOTIFS

7th Century to 4th Century B. C. GREEK Plate III



BAND

EGG AND TONGUE

BEADWORK

LEAF AND DART

GUILLOCHE

SCROLLWORK

ACANTHUS

ANTEFIXÆ

ANIMAL FORMS

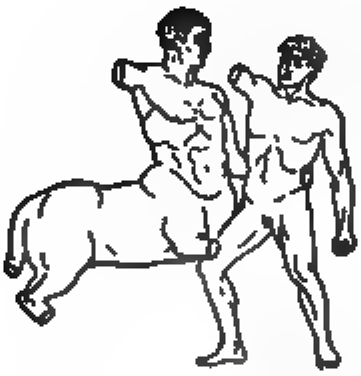
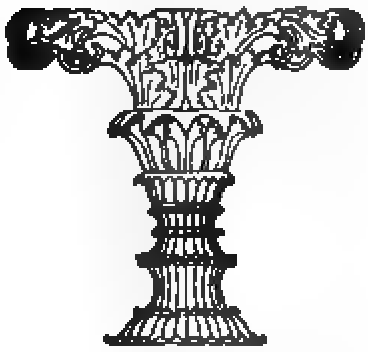
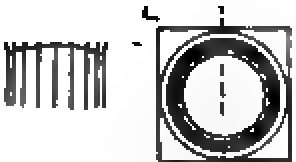


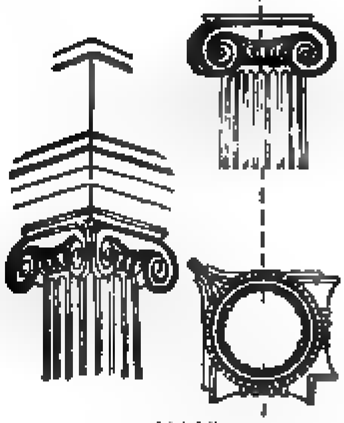
FIGURE WORK



FINIAL



DORIC

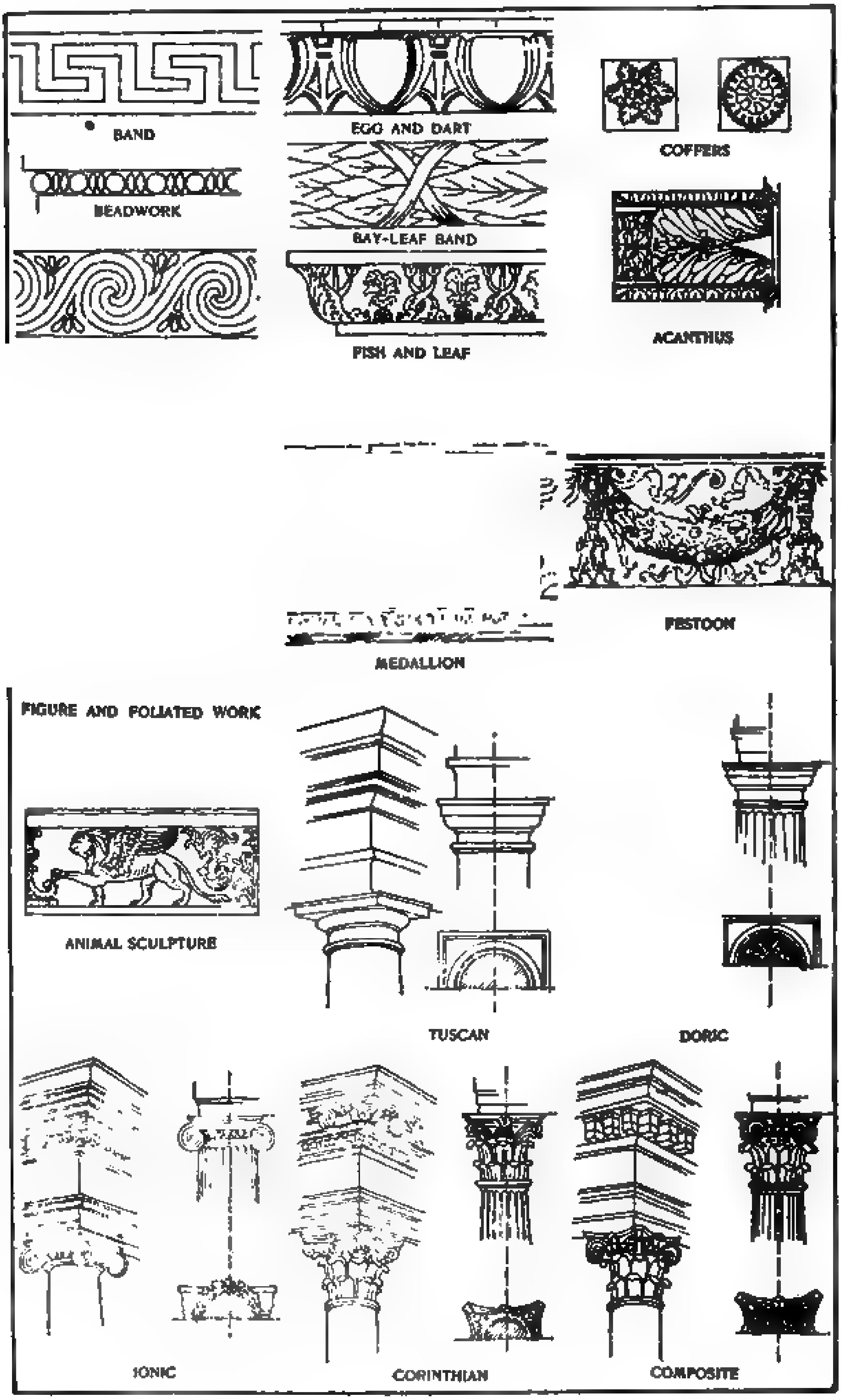


IONIC

CORINTHIAN

ORNAMENTAL MOTIFS

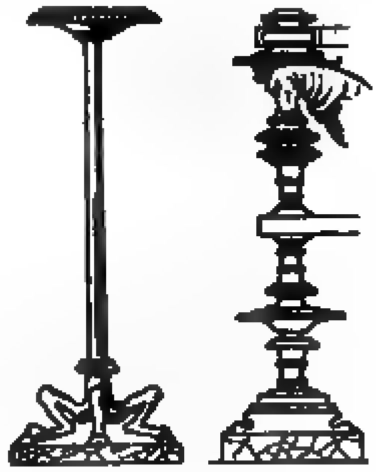
3d Century B. C. to 5th Century A. D. ROMAN Plate IV



ORNAMENTAL MOTIFS
POMPEIAN

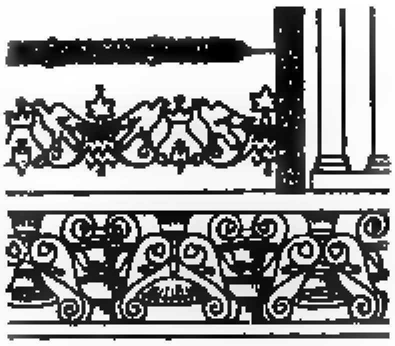
Destroyed, 79 A. D.; Rediscovered, 1748 — Plate V

FRIEZE TREATMENT



PANEL TREATMENT

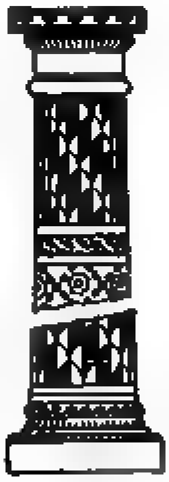
STANDARDS



WALL TREATMENT

ANIMAL FORMS

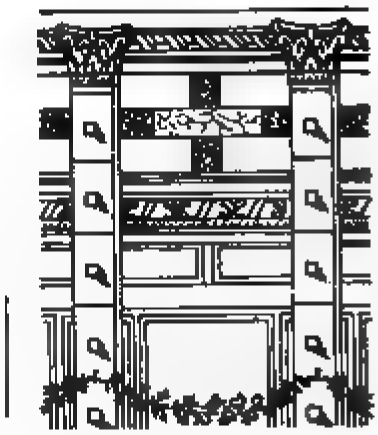
MASK

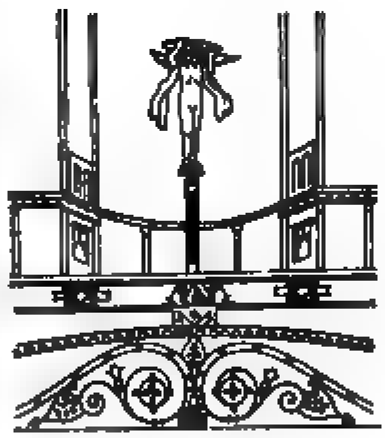


COLUMNAR

PERSPECTIVE TREATMENT

BRAZIER





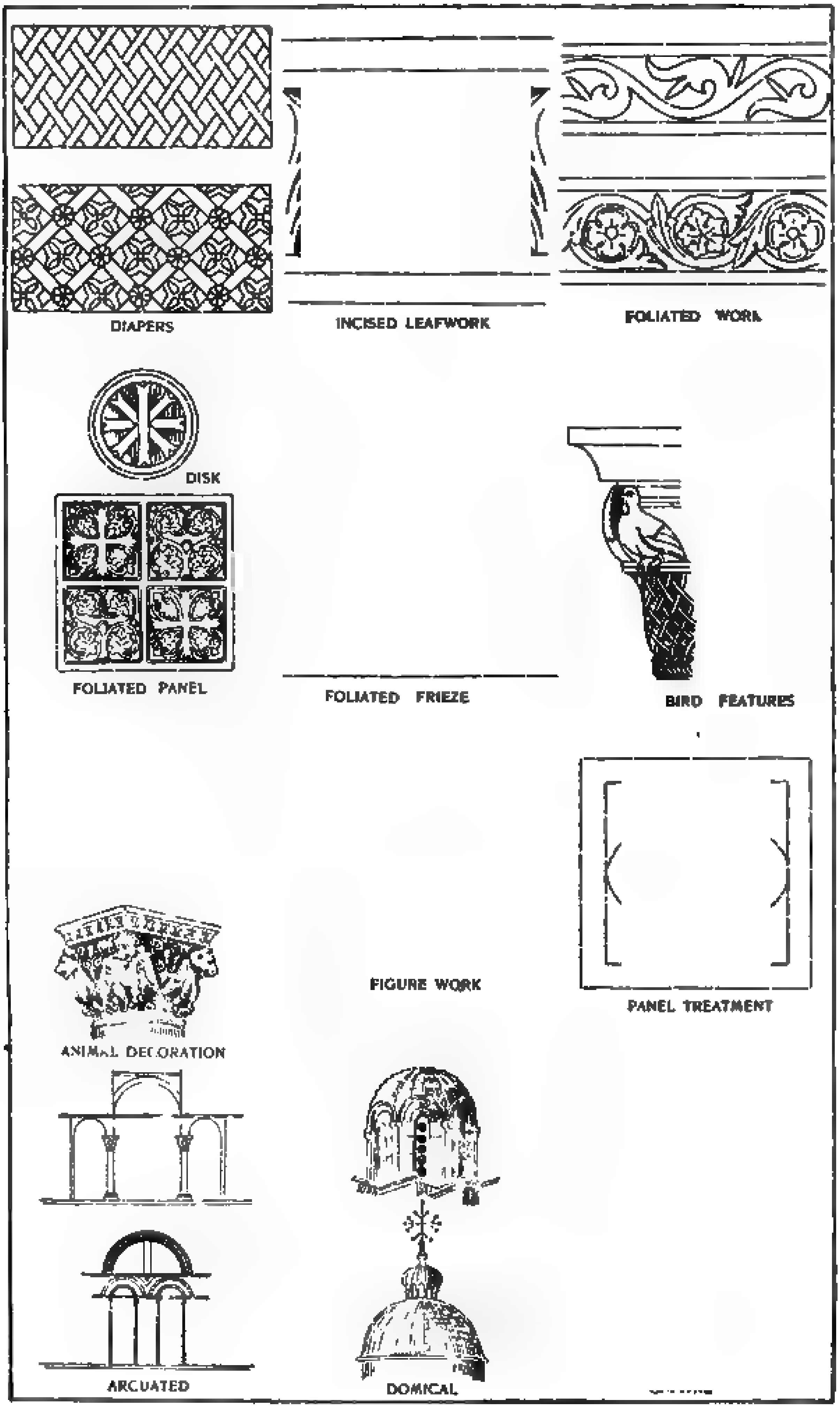
FIRST STYLE

SECOND STYLE

THIRD STYLE

ORNAMENTAL MOTIFS

330 to 1453 A. D. BYZANTINE Plate VI



ORNAMENTAL MOTIFS

1000 to 1150 A. D. — ROMANESQUE — Plate VII

INTERLACING

SCROLL FRIEZE

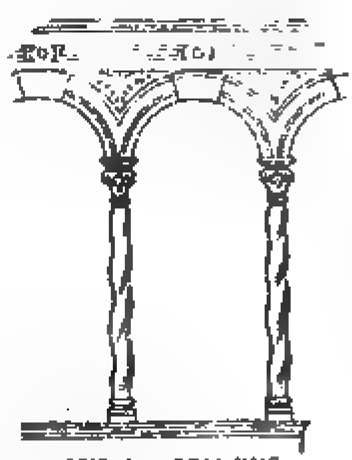
FLORIATED ORNAMENT

BIRD FEATURES

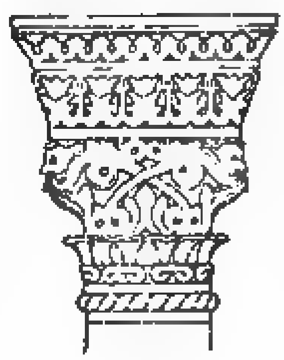
DIAPER WORK

CORBEL DECORATION

ARCH



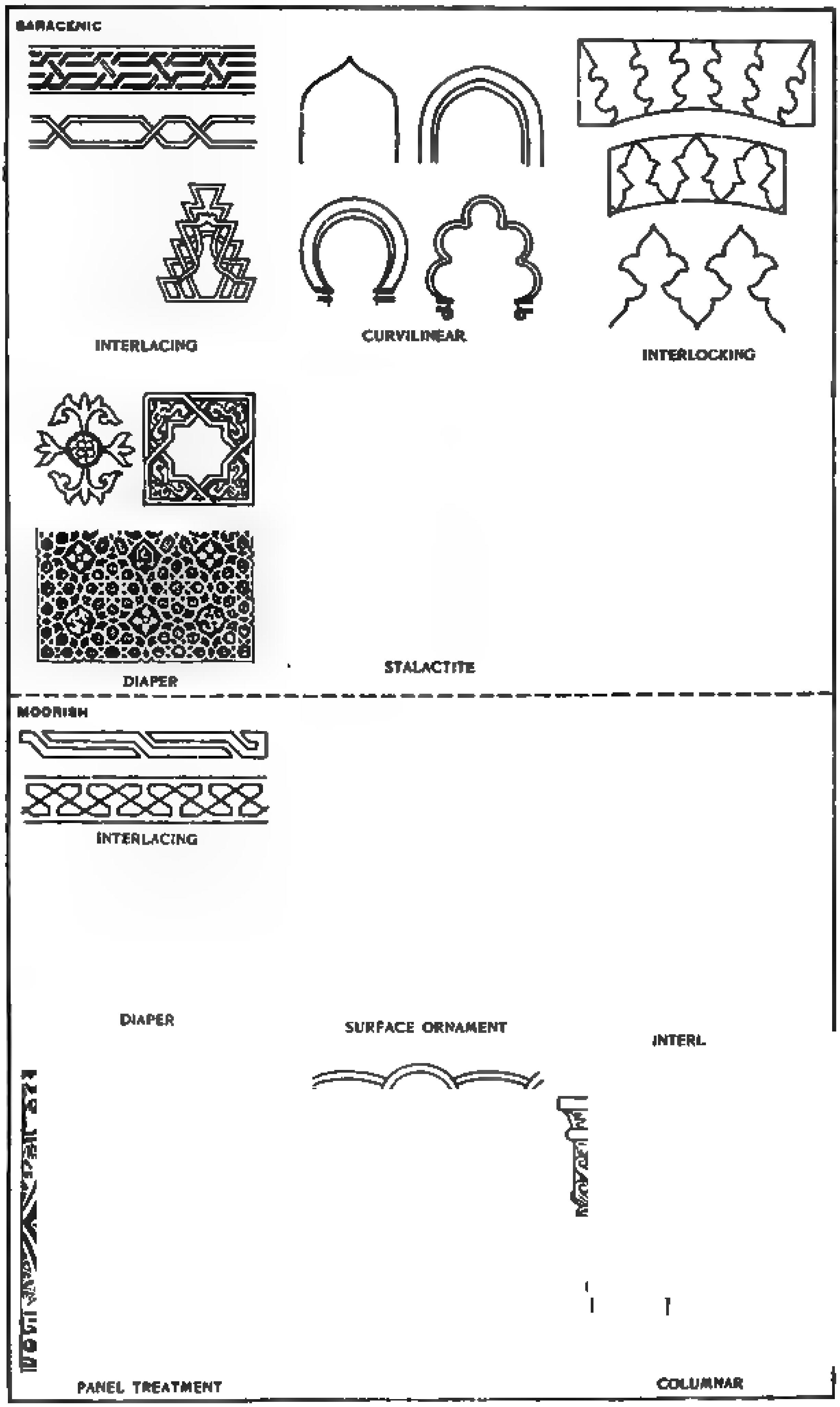
SPIRAL COLUMNS



CAPITALS

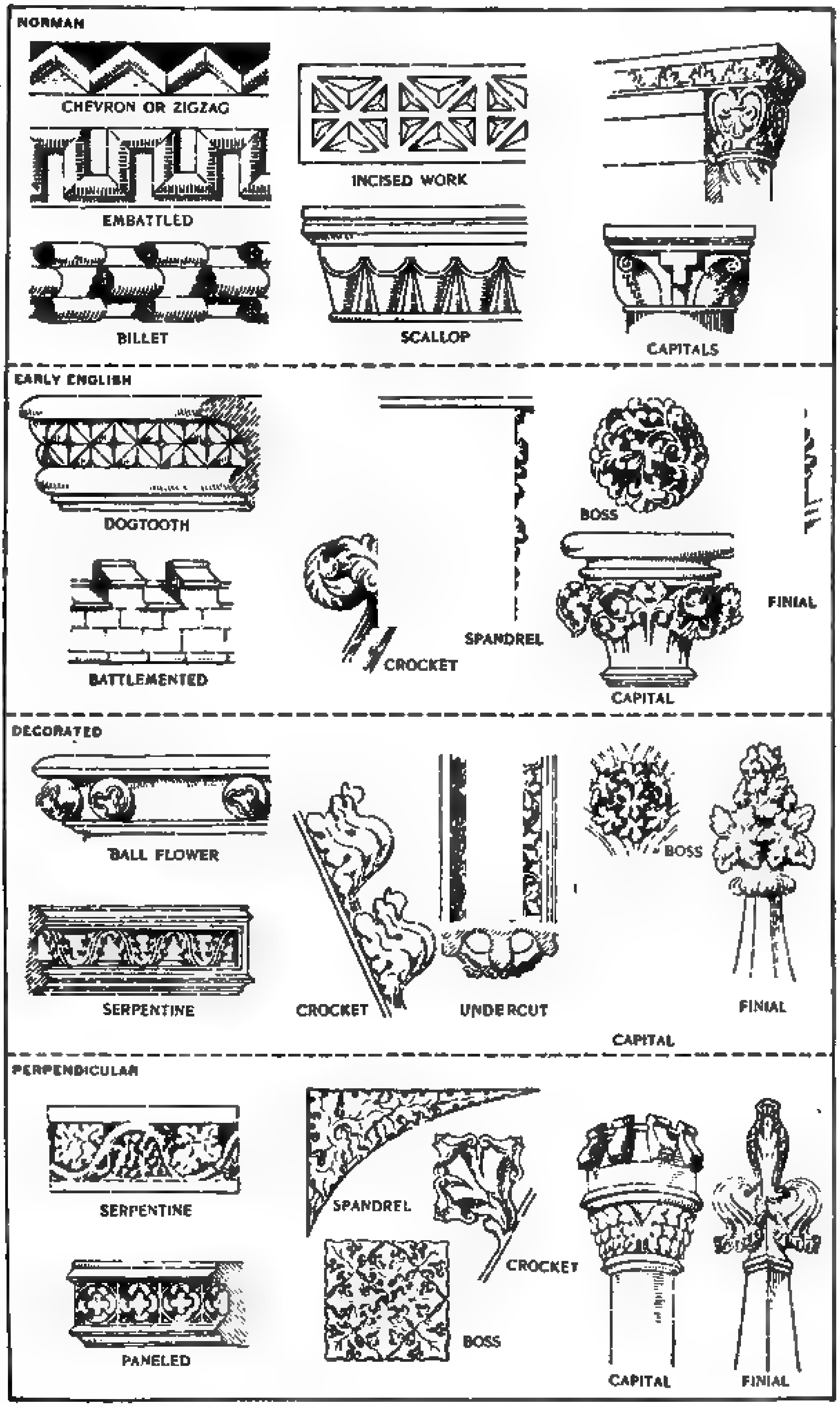
ORNAMENTAL MOTIFS

1250 to 1516 A. D. — SARACENIC AND MOORISH — Plate VIII



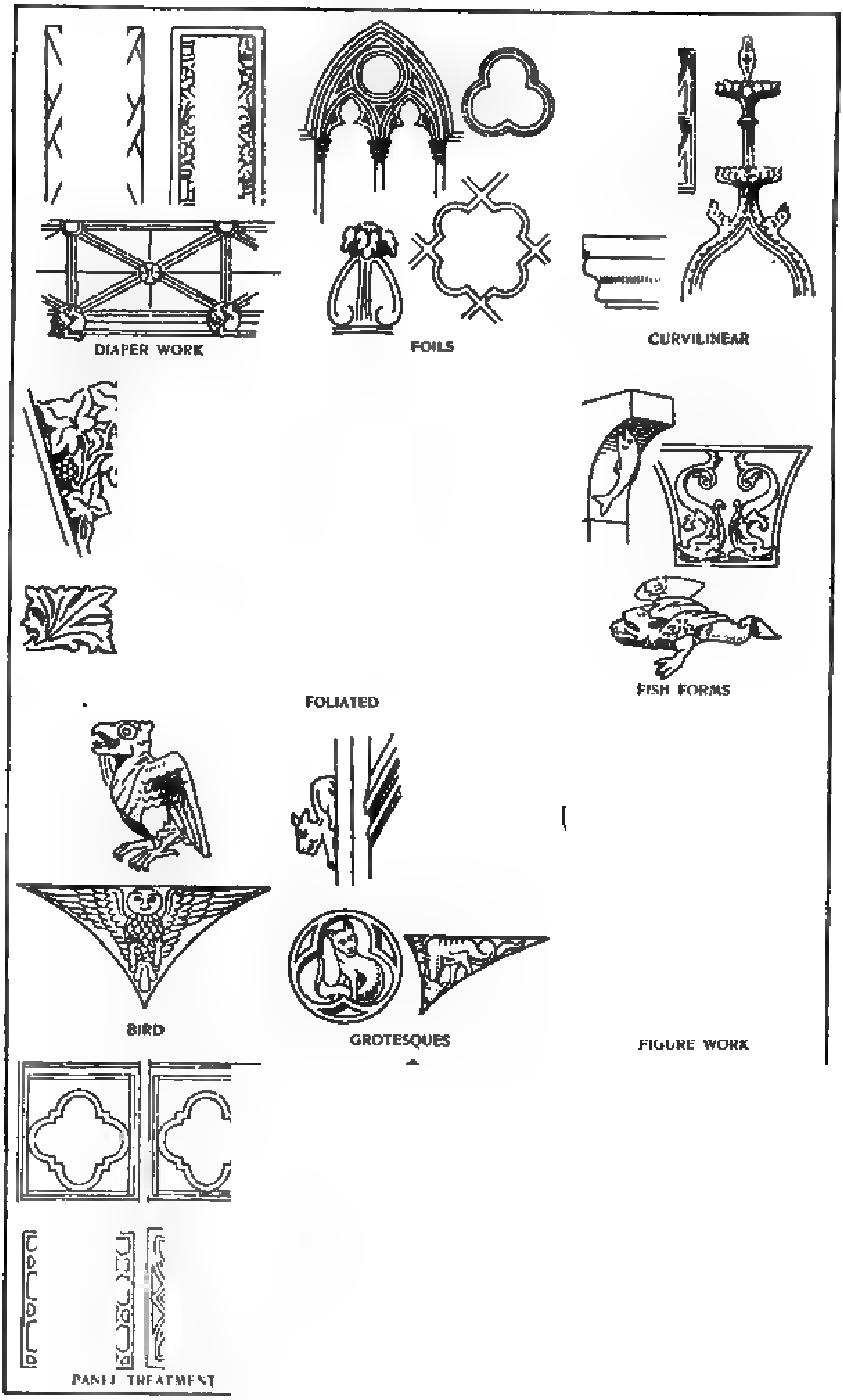
ORNAMENTAL MOTIFS

1066 to 1509 A. D. — ENGLISH GOTHIC — Plate IX



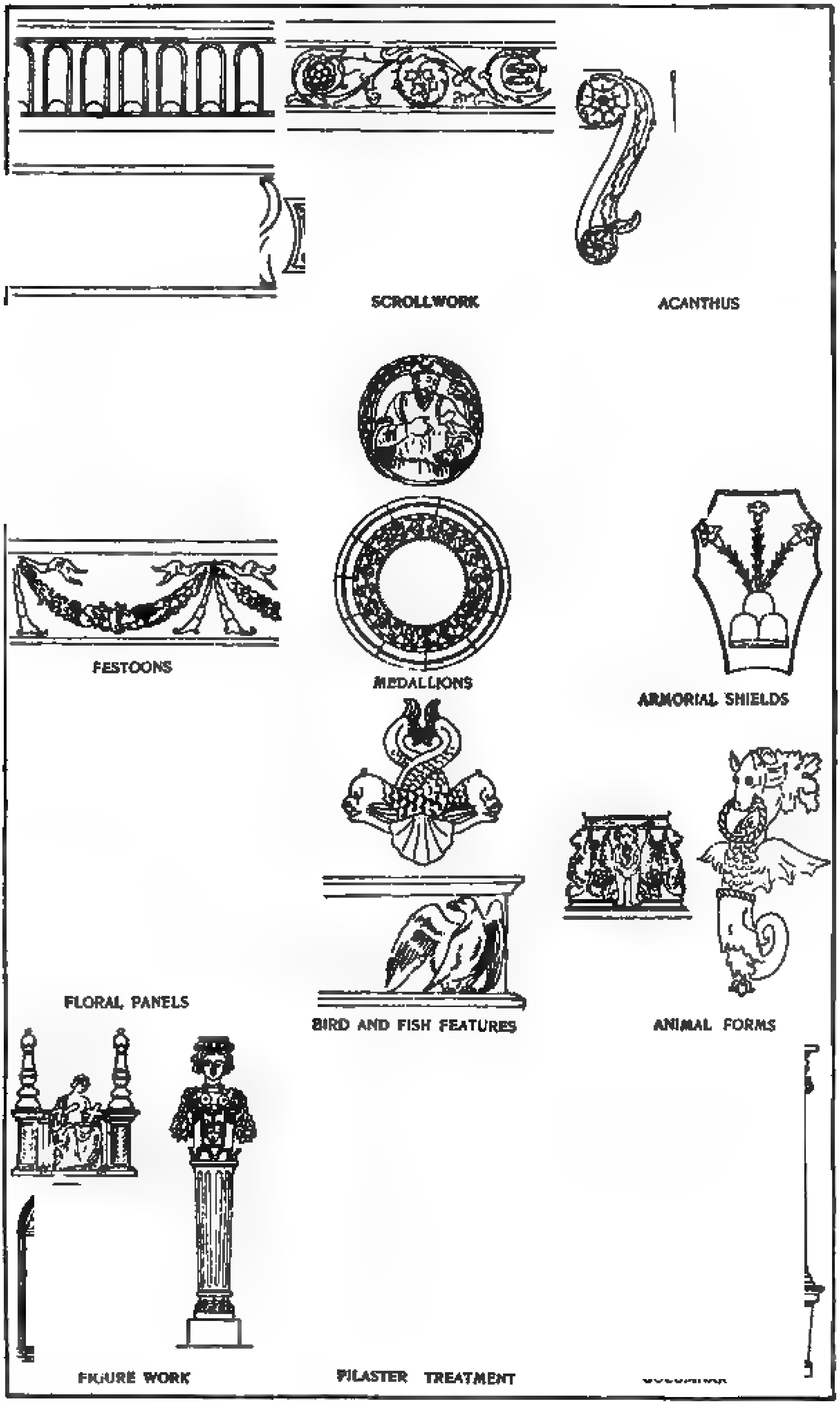
ORNAMENTAL MOTIFS

1150 to 1450 A. D. — FRENCH GOTHIC — Plate X



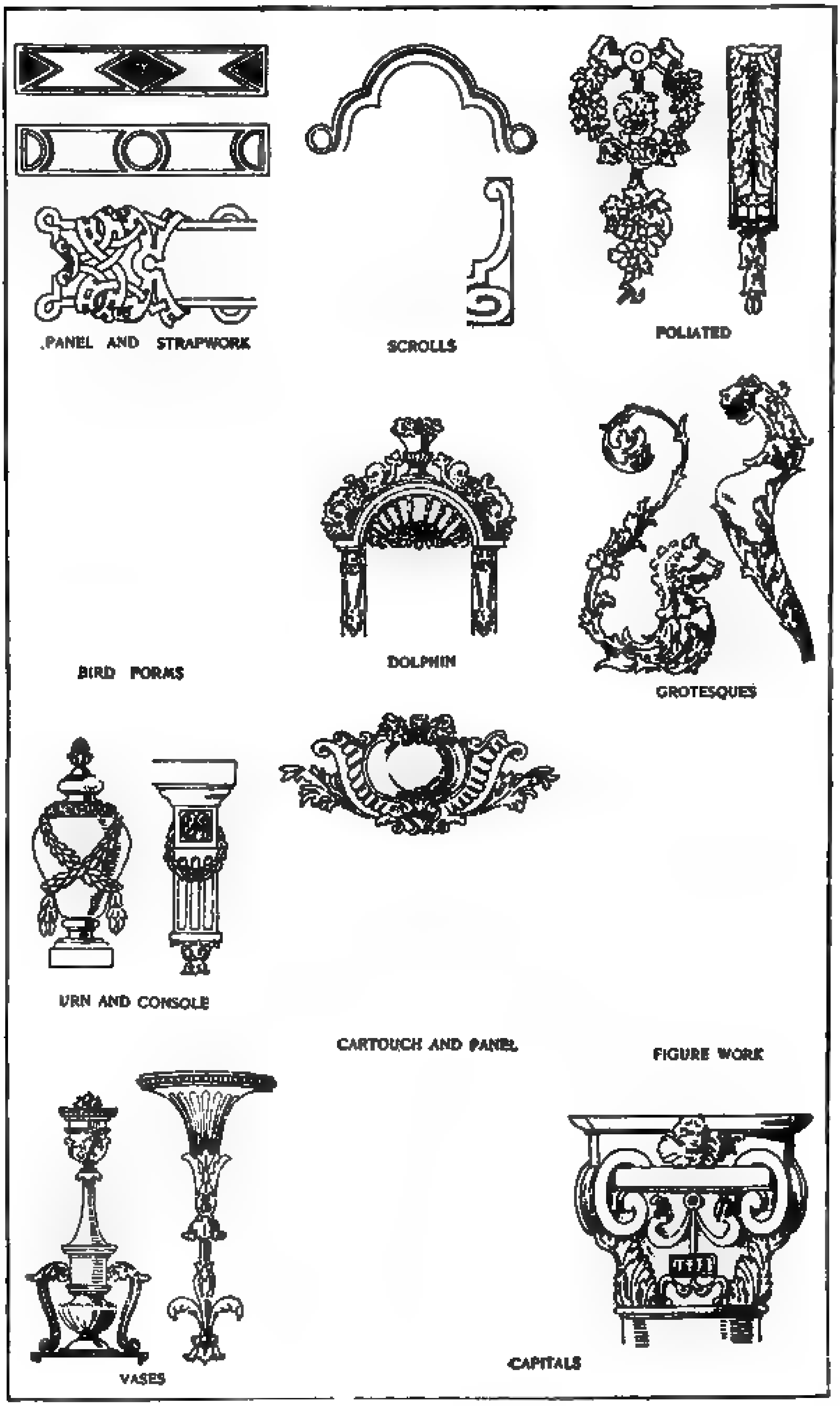
ORNAMENTAL MOTIFS

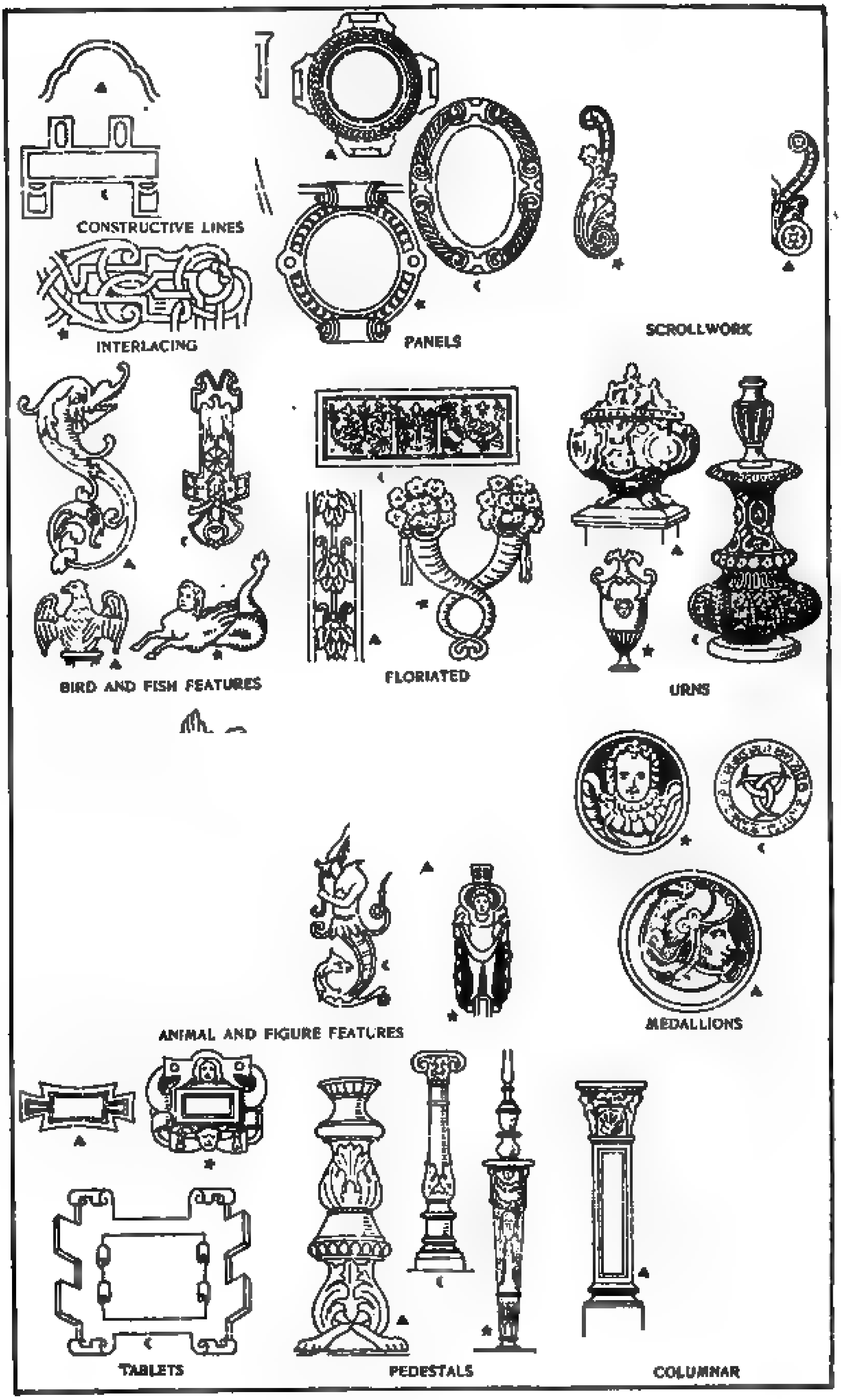
1400 to 1600 A. D. — ITALIAN RENAISSANCE — Plate XI



ORNAMENTAL MOTIFS

Various Schools | FRENCH RENAISSANCE | Plate XII

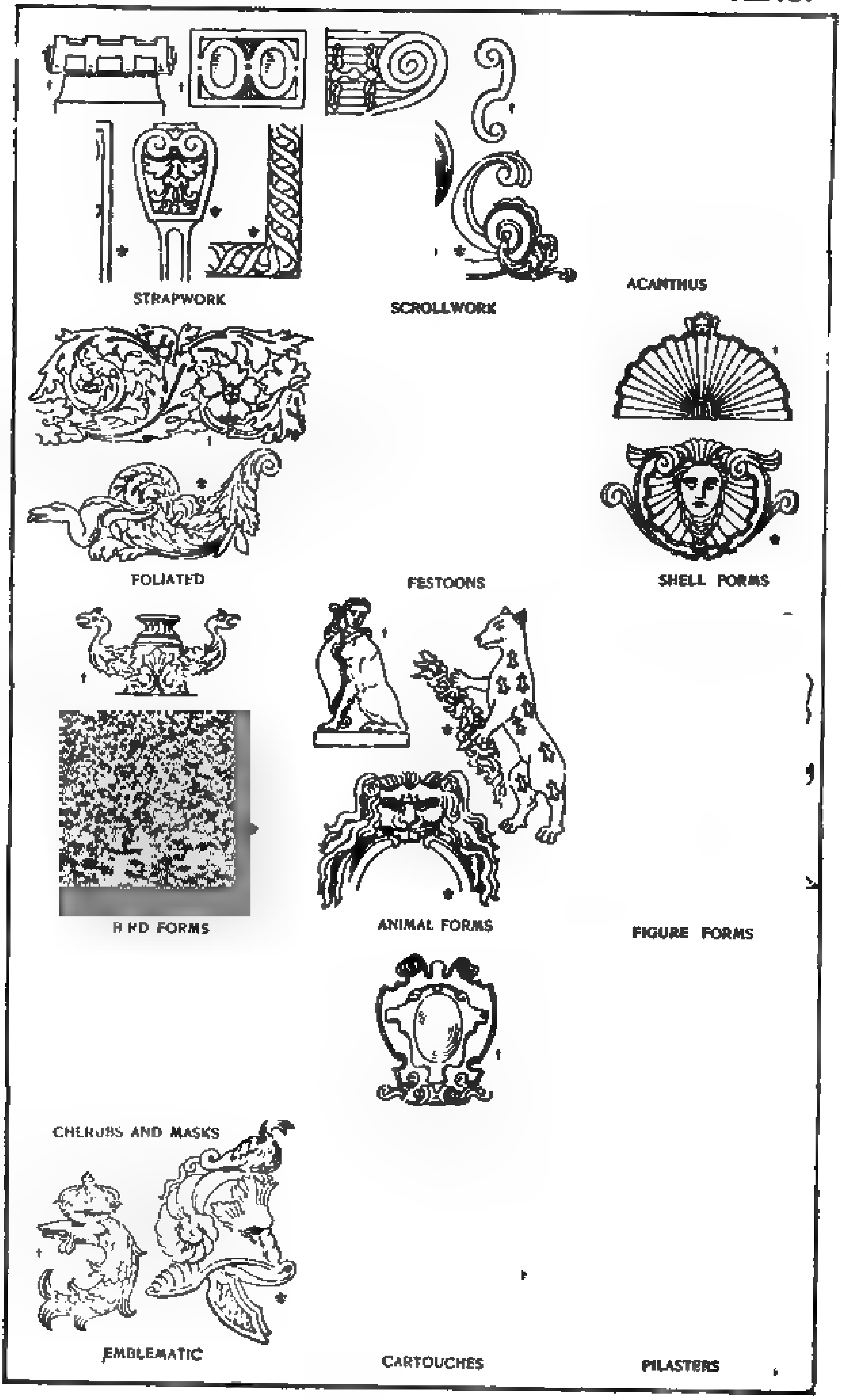




Francis I = ▲ Henry II = ☾ Henry III = *

ORNAMENTAL MOTIFS

1589 to 1643 A. D. — FRENCH RENAISSANCE — Plate XIV

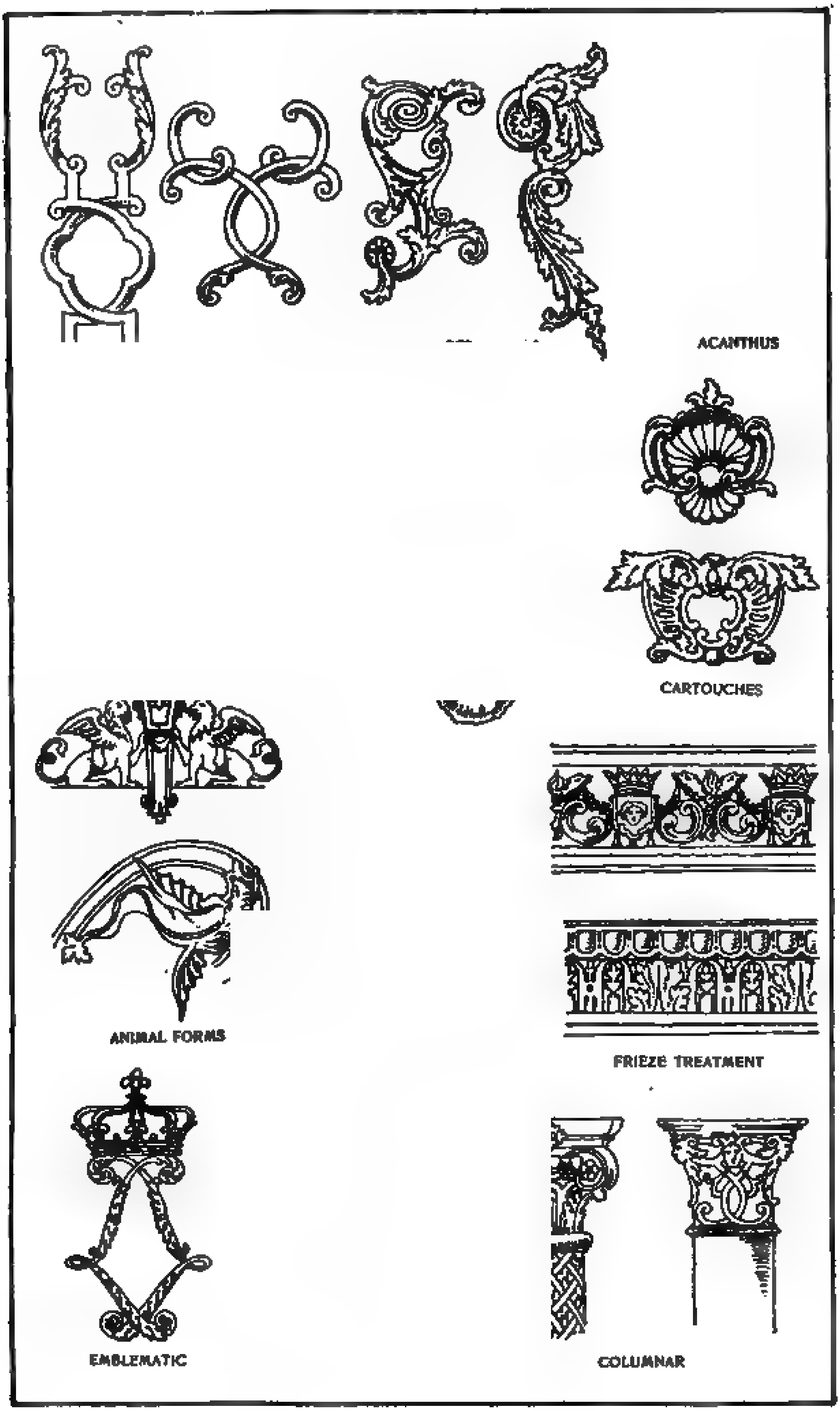


Henry IV = † Louis XIII = ✿

ORNAMENTAL MOTIFS

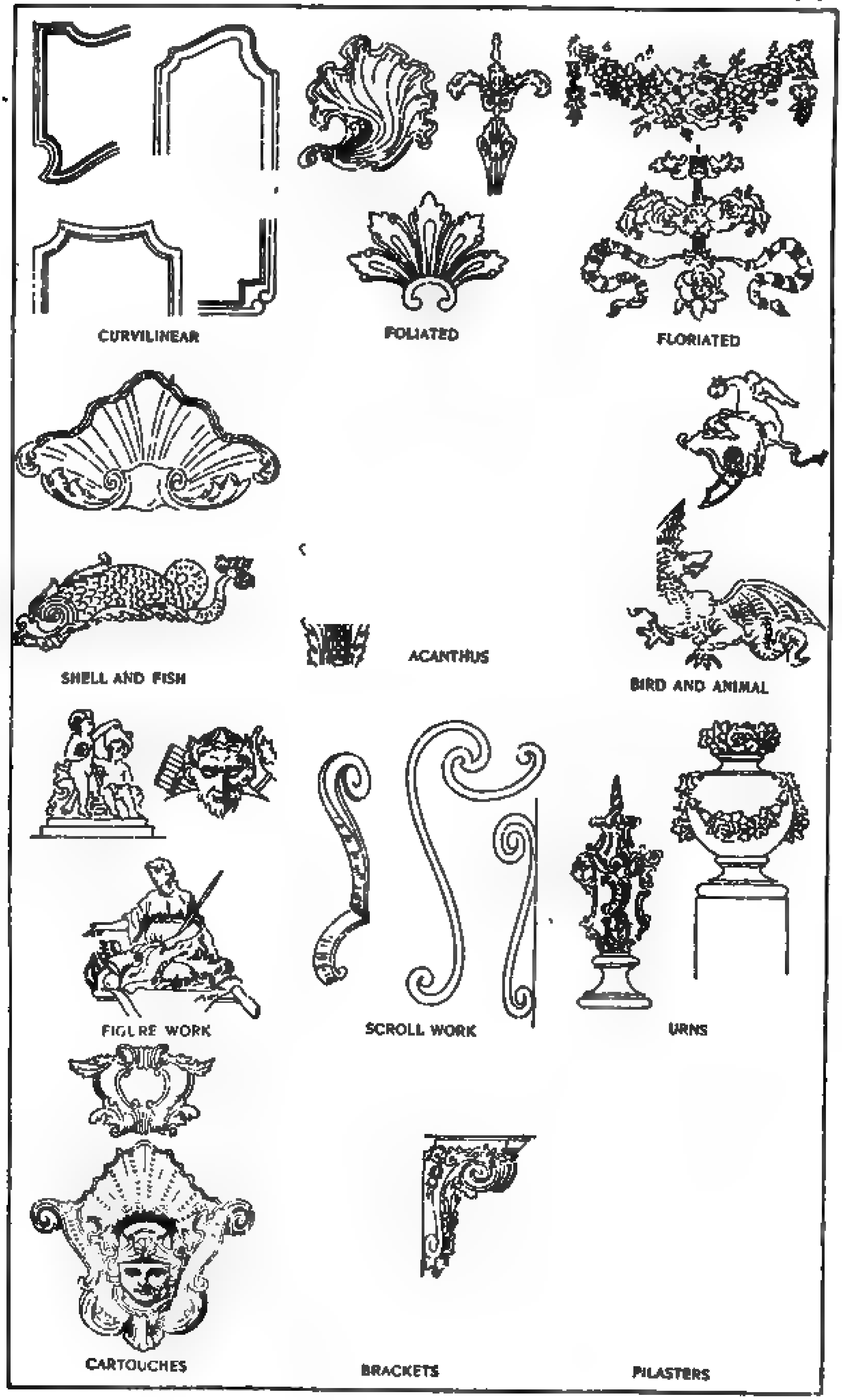
FRENCH RENAISSANCE

Louis XIV. 1643 to 1715 A. D. **Plate XV**



ORNAMENTAL MOTIFS
FRENCH RENAISSANCE

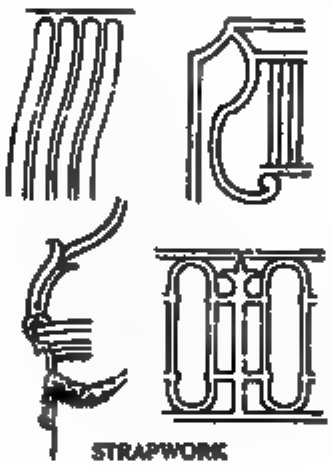
Louis XV. 1715 to 1774 A. D. Plate XVI



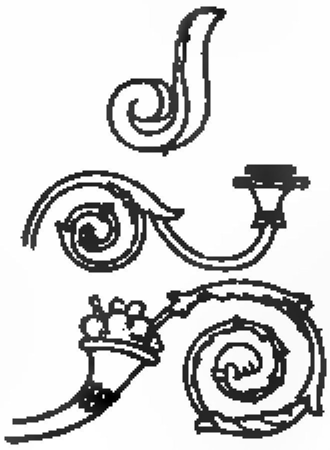
ORNAMENTAL MOTIFS

FRENCH RENAISSANCE

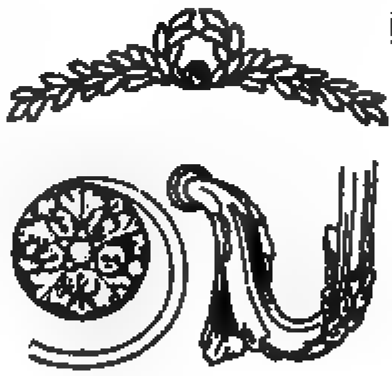
Louis XVI. 1774 to 1793 A. D. — Plate XVII



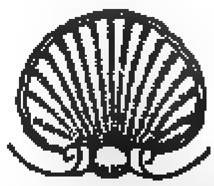
STRAPWORK



SCROLLWORK



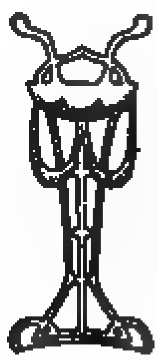
FOLIATED



SHELL

ACANTHUS

ANIMAL FORMS



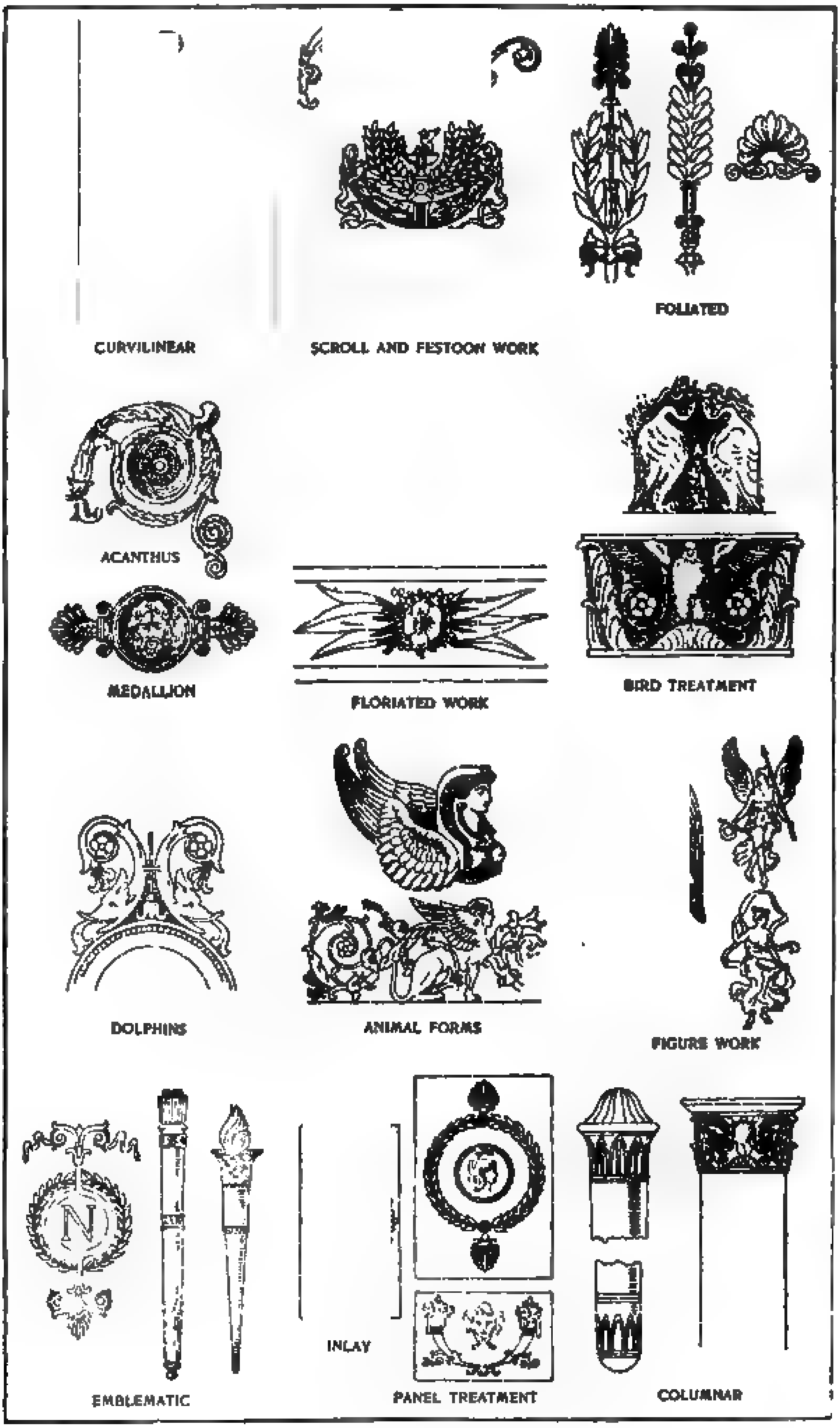
EMBLEMATIC

PANEL TREATMENT

ORNAMENTAL MOTIFS

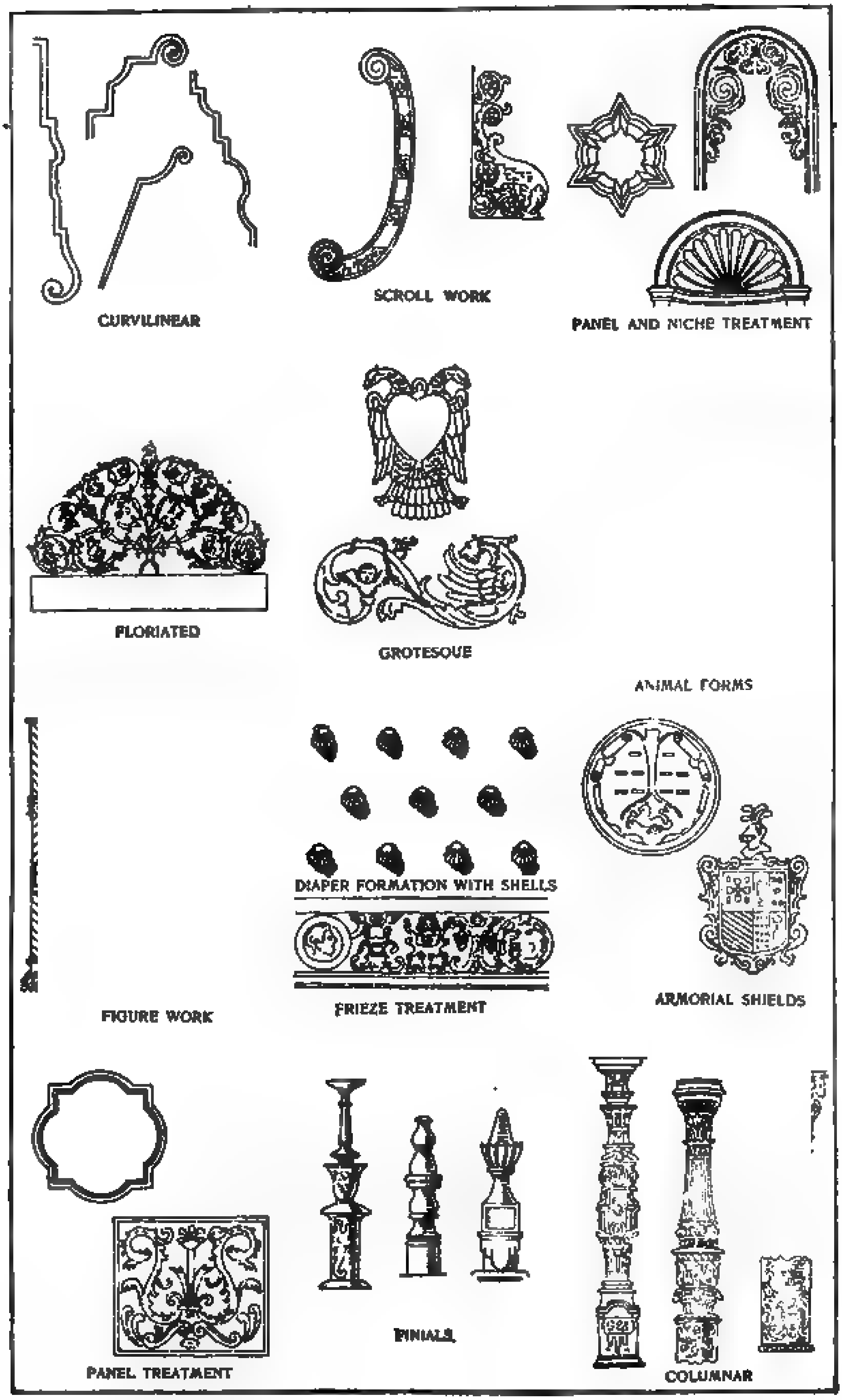
FRENCH RENAISSANCE

First Empire. 1804 to 1814 A. D. — Plate XVIII



ORNAMENTAL MOTIFS
SPANISH RENAISSANCE

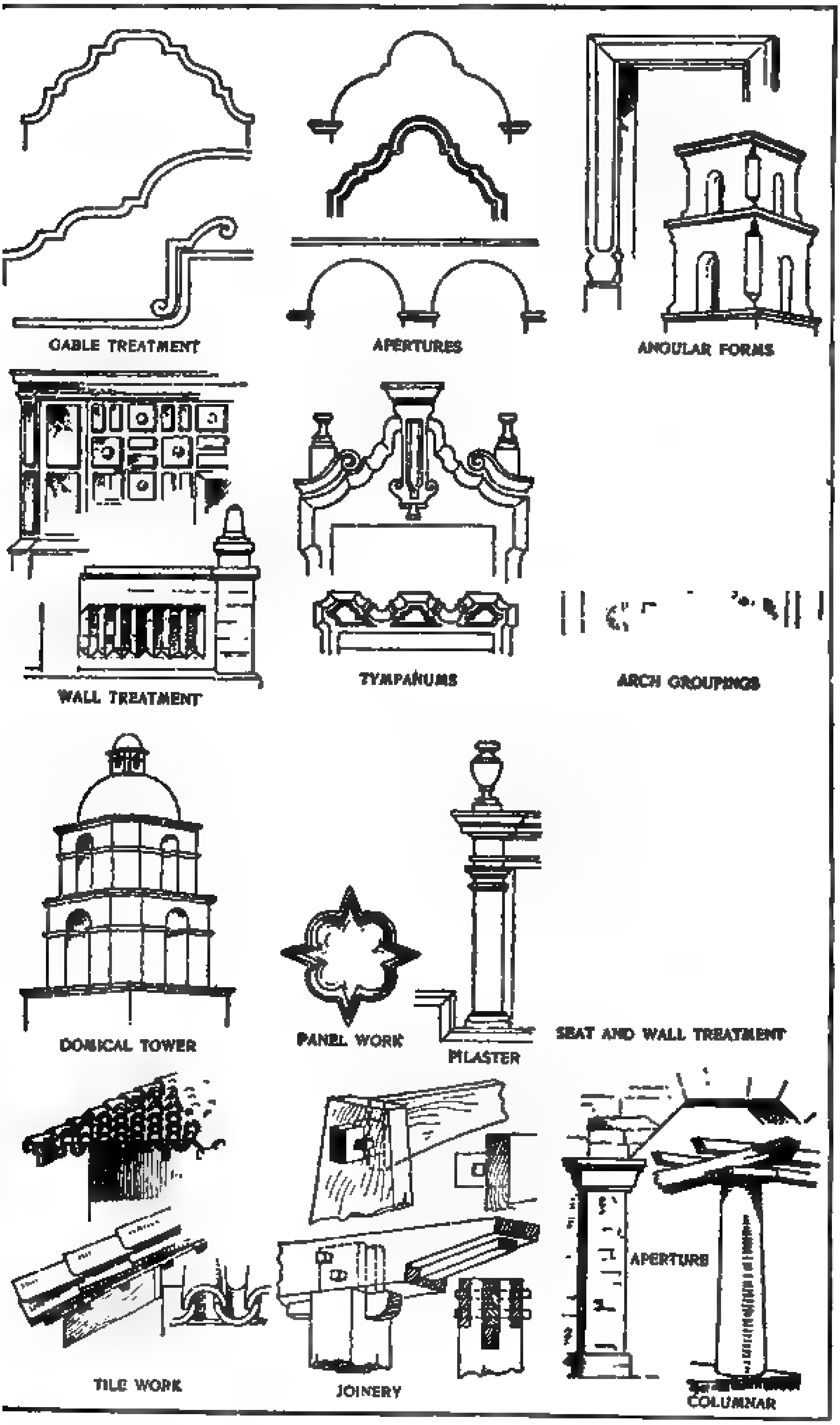
13th Century to 16th Century A. D. Plate XIX



ORNAMENTAL MOTIFS

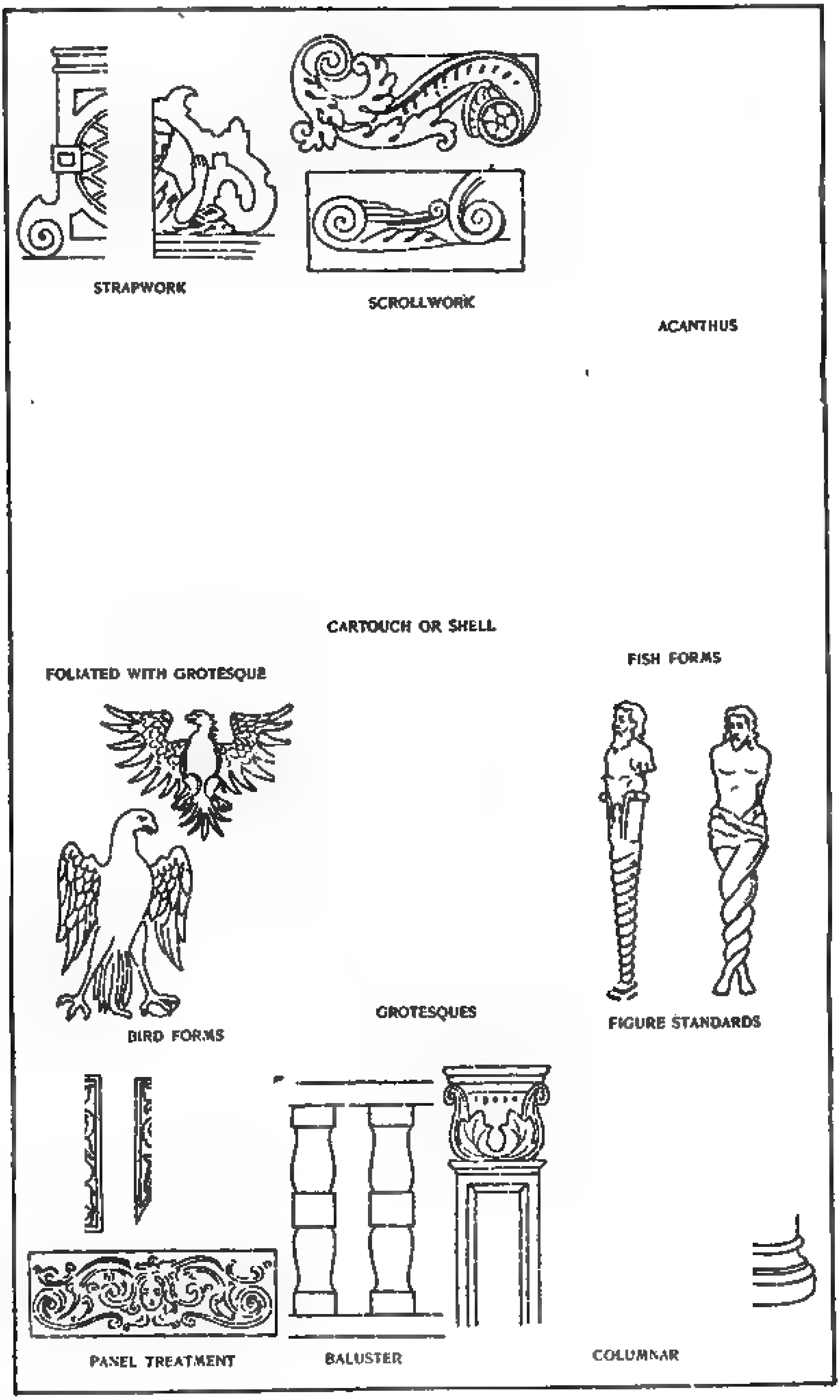
SPANISH RENAISSANCE

American Mission. 16th Century to 18th Century A. D. Plate XX



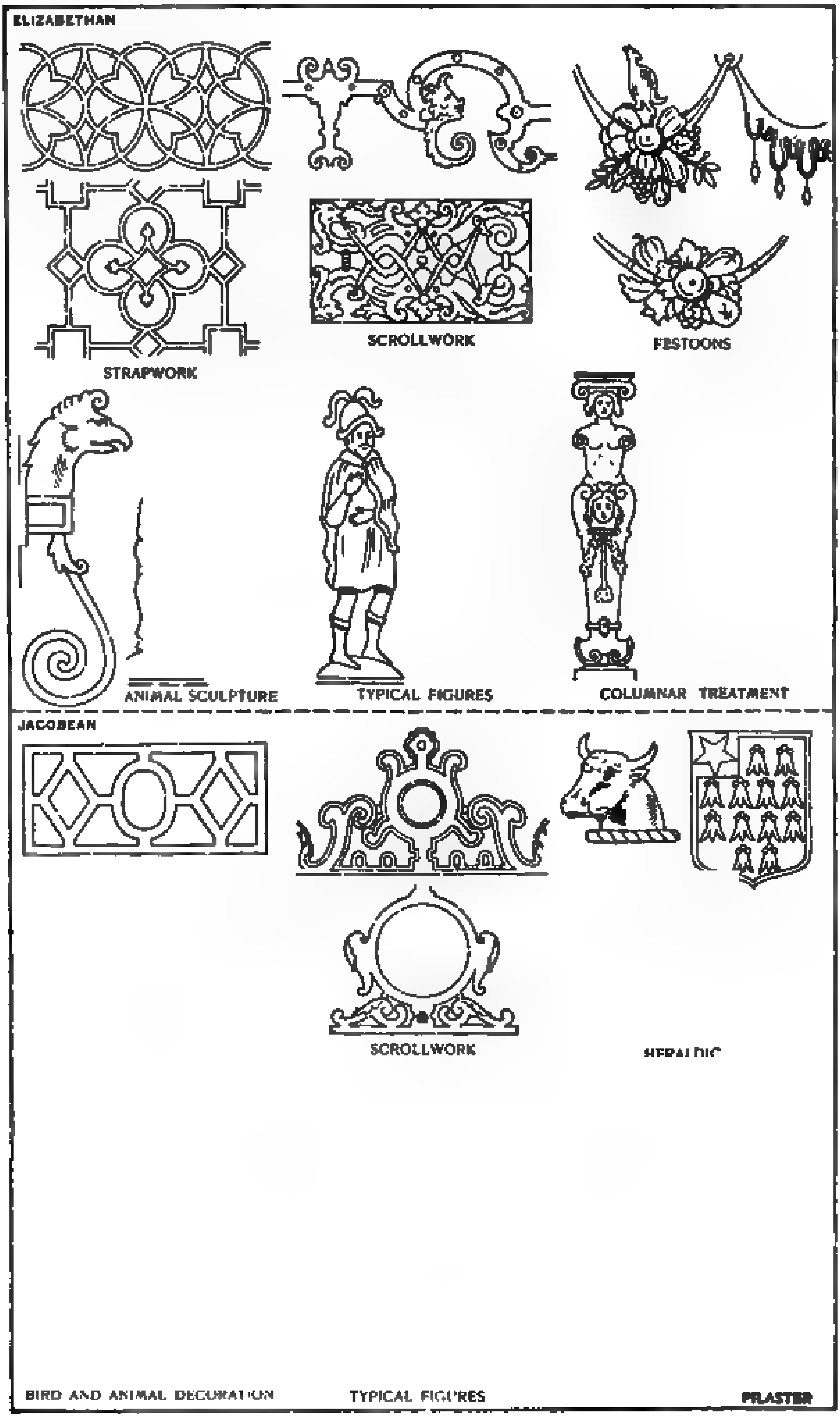
ORNAMENTAL MOTIFS

1493 to 1650 A. D. GERMAN RENAISSANCE Plate XXI

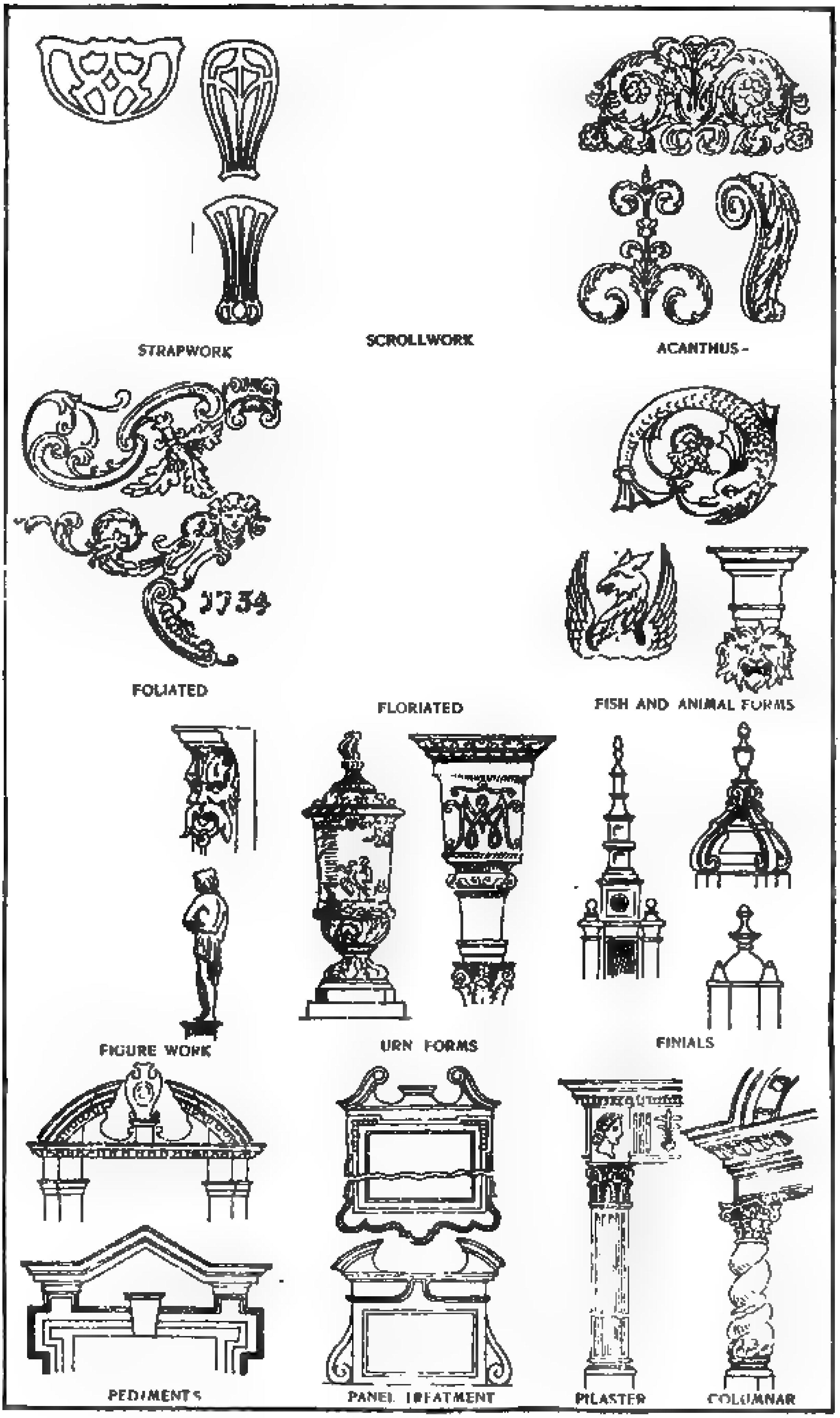


ORNAMENTAL MOTIFS

1558 to 1688 A. D. ENGLISH RENAISSANCE Plate XXII



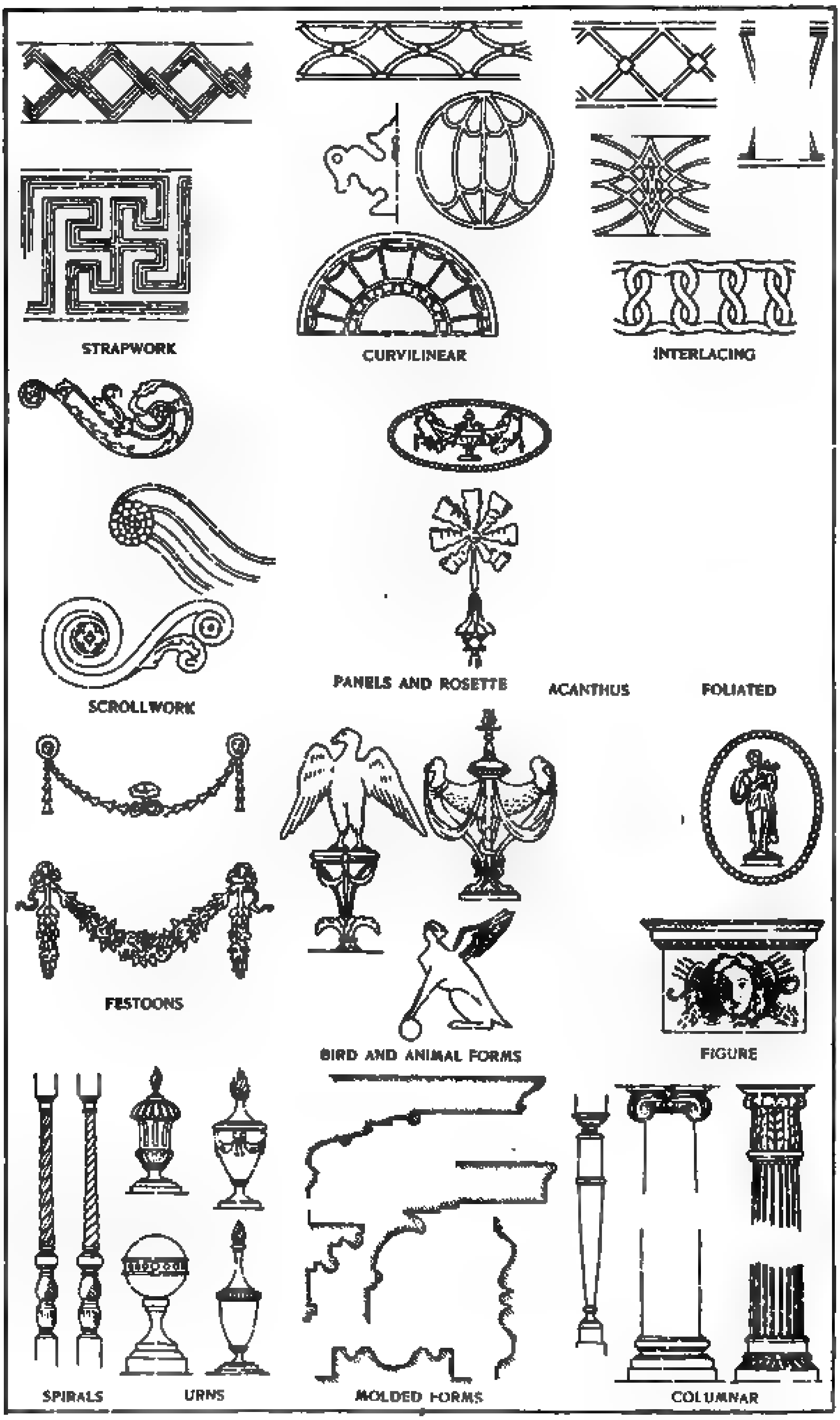
ORNAMENTAL MOTIFS



ORNAMENTAL MOTIFS

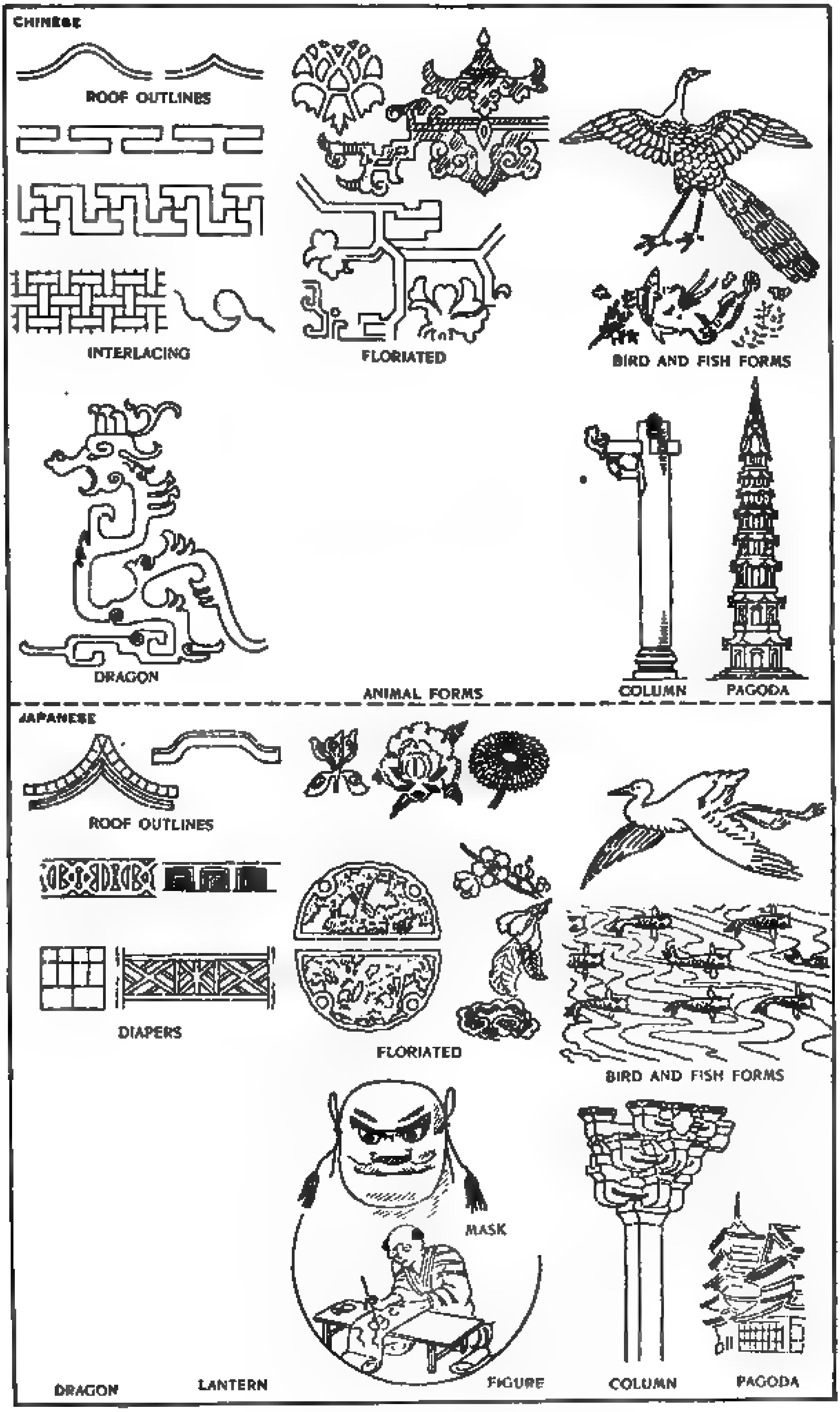
ENGLISH RENAISSANCE

American Colonial. 18th Century — Plate XXIV



ORNAMENTAL MOTIFS
CHINESE AND JAPANESE

Examples: 12th Century to 18th Century A. D. Plate XXV



MAKING OF SKETCHES

53. In preparing designs of fixtures for clients, the designer usually executes them in pencil, pen and ink, or water color, according to the demands of the design or the method in which he is most proficient. For example, if the fixture is to have a shade of colored glass, either leaded or in frames, or is to have a colored silk fringe, or is to be enriched with colored enamels, a water color will be necessary to illustrate the purpose of the designer. However, if the color scheme is not important, either pen and ink or pencil will answer the purpose.

It will be noted in the specifications that follow that if the proposal and designs are accepted, the latter become a part of the specifications, and thus a part of the contract. The importance of clear and exact drawings is therefore evident.

SPECIFICATIONS

54. In order to show the conditions under which the manufacturer works with relation to the architect and Board of Underwriters, the rules and regulations governing fixture making required by architects and owners, called **specifications,** which are submitted to the manufacturers competing for the work, will now be considered. As specifications vary according to the nature and use to which the building is to be put, it will not be necessary to enter into details, and a general arrangement only will be given. Copies of the rules and regulations of the National Board of Underwriters may be procured by applying to the secretary of that organization, whose address may be obtained from any fire-insurance agent.

55. General Conditions.—The drawings and specifications are intended to cooperate, but any work shown on the drawings and not particularly described in the specifications, or vice versa, and work evidently necessary to the complete finish of the electric or gas-lighting equipment, even if not specified or shown, is to be done by

the contractor without extra charge, the same as if it were both specified and shown.

56. Measurements.—The contractor must verify all measurements by actual measurements at the building and fit his work to the building as erected, whether it is exactly in accordance with the plans or not.

57. Drawings.—Shop drawings, copies of the drawings furnished, templets, reverse templets, patterns, models, and all necessary measurements at the building are to be made by the contractor at his own expense. Figured dimensions on the drawings are to be followed in all cases in preference to scale measurements.

58. Extra Work.—No extra work will be allowed unless ordered as such by the architect in writing. No bill for extra work so ordered will be approved unless it is rendered immediately upon completion of said work.

59. Authority of Architects.—All questions arising as to the true intent and meaning of the plans and specifications, and as to the obligations of the contractor relating to the contract for this work, are to be decided by the architect, and his decision shall be final.

60. Material and Workmanship.—All materials of every kind and description are to be of the very best quality, and all work necessary to completely finish the lighting fixtures, as shown on the drawings, and as directed by this specification, is to be executed in the most thorough, substantial, neat, and workmanlike manner, to the entire satisfaction of the architect, who shall be given every opportunity to inspect the work as it progresses. All work must conform in every respect to the rules and regulations of the National Board of Fire Underwriters, and these rules wherever pertinent are hereby made a part of these specifications.

61. Gas Piping.—The gas piping for all fixtures is to be of wrought pipe not less than $\frac{1}{2}$ inch in stems over 4 feet long, not less than $\frac{3}{8}$ inch in stems less than 4 feet long, and not less than $\frac{1}{4}$ inch in arms.

62. Castings.—All castings are to be of bronze or brass, sound and free from blowholes and other imperfections, and heavy enough for the positions they are to occupy in the completed fixtures.

63. Tubing.—All tubing is to be of brass, seamless drawn, and in no instance smaller than No. 18, A. W. G. All curves are to be true and accurately bent, without indentations or other defects.

64. Insulating Joints.—Every plain electric and combination fixture is to be equipped with a MacAllen insulating joint or some make that is equally as good and has the architects' approval.

65. Canopies.—Every canopy is to be so constructed that it can be readily removed or shifted sufficiently to afford easy access to the insulating joint and wire connections.

66. Finish.—All fixtures are to be finished in the most thorough manner, and with a uniform line on all parts; all exposed surfaces are to be well lacquered.

67. Assembling.—The fixtures must be assembled with the greatest care, and all parts must fit together accurately and securely. All joints in the gas piping are to be thoroughly cemented, and all joints in the wiring are to be securely soldered and taped.

68. Erecting.—The contractor shall erect all fixtures, making all gas and electrical connections and furnish all nipples, wire, tape, etc., required for a perfect installation. All gas joints are to be thoroughly cemented, and all electrical connections are to be made in the same manner as specified for fixture winding. All canopies shall fit close up to the finished ceilings and walls, and when canopies are placed against ceiling arches, partition corners, or other similar surfaces, short-extension split rings shall be used to close up the resultant gap. No covering tubes or ceiling plates whatever shall be installed back of canopies.

69. Designs.—Bidders must submit a drawing of each fixture intended for the following outlets, and upon the acceptance of any proposal, the drawings upon which it is based are to become a part of these specifications, and are to be marked for identification by the architect.

The designs required are:

(Here fohows a list of the designs desired, giving in detail the nature of the composition, the form, the style of ornaments, and the place where each fixture is to be installed.)

ARCHITECTURAL DESIGN

INTRODUCTION

1. Architectural design does not consist of the introduction of standard conventional forms of a historic character into a building composition, but of the disposition and arrangement of masses of light and shade—wall openings and wall solids—and the proportioning of parts so as to establish a feeling of balance and harmony and to please the senses. Mechanical design, on the contrary, consists of the proportioning of parts and materials to serve some useful purpose and to satisfy the demands of strength.

The thickness of a stone pier, the depth of a lintel, or beam, between two piers, or the proportioning of a wall according to its height, is a matter of mechanical design, but the grouping of the piers or the introduction of molded lines so as to divide the surface of the walls into panels of varying proportions for the sake of appearance, is a matter of architectural design. Generally speaking, architectural design consists of the artistic grouping of the structural necessities and the emphasis of these necessities by ornament, but scientific construction must always be the first consideration.

2. A building must be planned first to suit its purpose exactly. Every detail must be proportioned to every other detail in order that there may be no cramping for space in one part and superfluous space in another. Consideration must always be given to every utilitarian element that enters into the purpose of each equal subdivision of the plan; therefore, the most important consideration in architectural planning is *utility*.

In order that the building itself may present fully the utilitarian advantages expressed in the plan, the construction must be perfect, and the methods of construction should be considered and worked out with the planning of the building and not left until the actual building operations are commenced.

The construction, from an architectural standpoint, should present a satisfactory appearance of strength to the eye, and the strengthening details should be so distributed as to lend variety to the structure itself. The proportioning of structural parts will depend on the material used, and the character of the material should therefore never be disguised, but always worked to show up to its own advantage and express architecturally its own strength and purpose.

3. For that reason, a design should always be worked out mentally before any attempt is made to lay it out on paper. If the design be for a house, then the whole house, including its arrangement of rooms, its general proportions, its color, and its outline against the sky, should be pictured mentally. This mental picture need not be exact, but it should give a definite basis on which the designer may work.

When a designer starts the design of a tomb modeled after a classic temple, his mind pictures a rectangular building with a low, gabled roof or something similar. When he designs a Gothic church, his mind pictures a crucial ground plan, buttressed walls, pinnacled gables, and towering spires.

However, tombs may be built in other styles, and churches need not be Gothic. Residences existed in all ages, and there is such a variety of form and device that can enter into their composition that the designer is likely to become reckless with such a wealth of material to choose from, and will work out his design independent of any fixed idea, trusting to the suggestions that occur to him as he proceeds with the work. This is all wrong, and only by frequent experiments and alterations, both in plan and in elevation, can the ideal be realized and perfection and proportion of form be brought about in the design for any individual purpose.

DESIGN AND COMPOSITION

ELEMENTS OF DESIGN

4. A design for any purpose will always represent one of two forms: that of a *surface* or that of a *solid*. In the one case, there is more or less of a given space to fill with appropriate and pleasing forms that are suited to their place and purpose. In the other, there are three or more sides to be considered separately or together, according to their purpose in enclosing the solid, and frequently a further consideration that exists within the solid itself, such as rooms and their relations.

As a surface design is nearly always viewed as a surface and is not materially affected by the point of view, it can be designed simply as a surface. A solid, however, materially changes in appearance according to its position above or below, or to the right or to the left, of the eye, as in these different positions its surfaces vary in proportion to each other and present varying appearances; hence, a solid should be designed in perspective.

5. Surface Designs.—The first subject to be considered is a surface design in which the designer is limited by given structural lines that are unalterable in general position, but may be changed somewhat in form to suit the esthetic ideas. In Fig. 1 are shown four combinations of straight lines. In (*a*) is a simple zigzag, or reversible, pattern; and in (*b*), a simple quarry, or series of squares. In (*c*), the interlaced lines form diamonds, or lozenge shapes, and at (*d*) are shown equilateral triangles. Let it be assumed that these lines are to form the structural elements of a design such as a leaded-glass window, an iron grille, or some other subject, and that it is desired to change the straight lines to curves, so as to

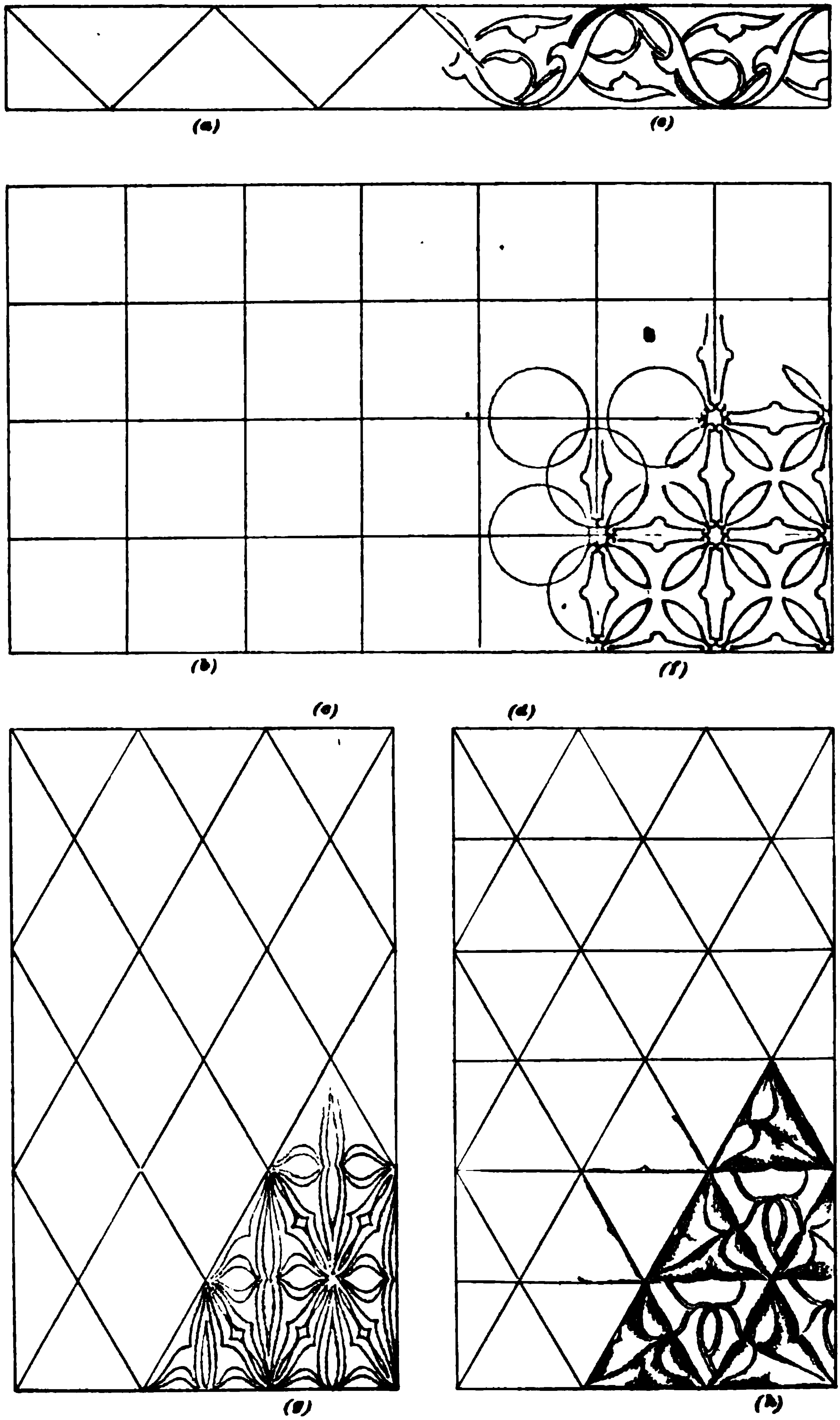
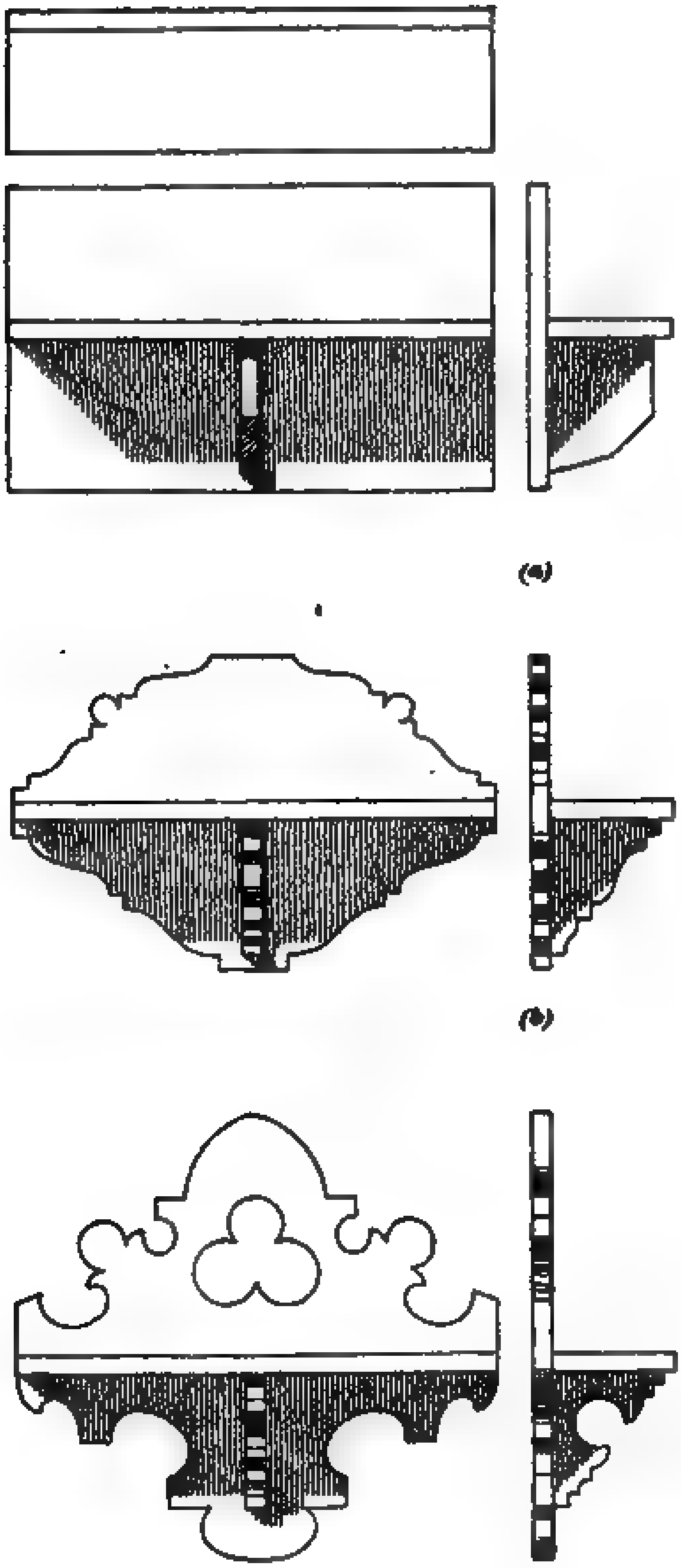


FIG. 1



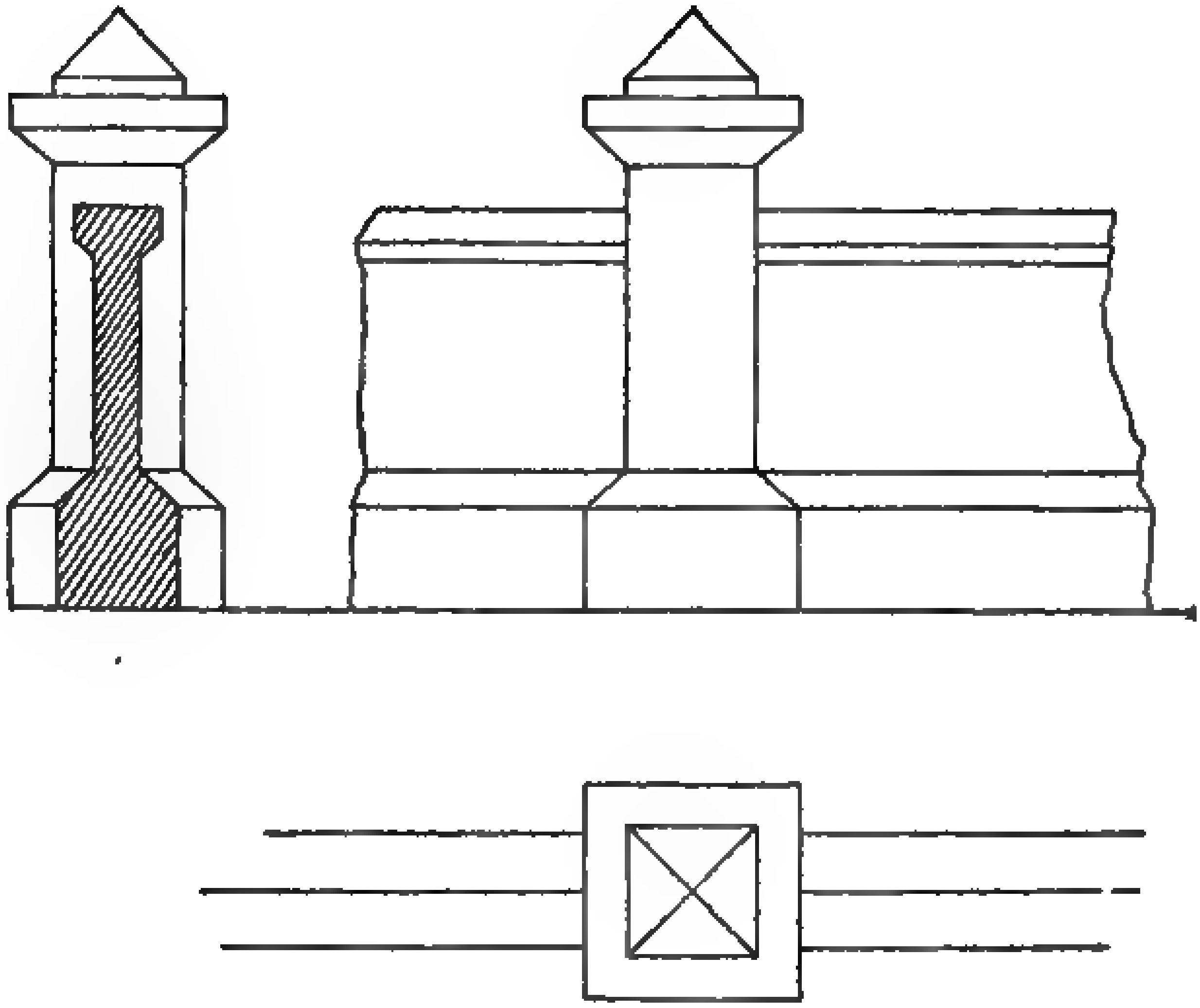
(c)
FIG. 2

make the proportions pleasing, introducing other lines where necessary to carry out the idea of the design, but exercising great care not to disturb the structural character of the given lines. This character may be retained both by changing the straight lines to curves and by making a variation of light and shade values between certain surfaces that are so bounded. Several results that can be obtained under these restrictions are shown at (*e*), (*f*), (*g*), and (*h*), which are designs worked out on the lines.

6. Where an object is composed of several surfaces that are introduced purely for purposes of utility, it may be made ornamental by giving these surfaces a pleasing outline. But care should be taken that the structural lines are not lost nor the utilitarian purpose of the object impaired by the treatment.

In Fig. 2 (*a*) are shown the plan, elevation, and perspective views of a wooden bracket with a backboard and shelf. This bracket consists simply of three pieces of 1-inch plank put together in the manner shown. So far as its utilitarian purpose is concerned, the shelf is very satisfactory and will carry all that was intended for it; but if curves are substituted for the straight lines, wholly or in part, the entire character of the bracket may be changed, and without losing in the slightest degree any of its utilitarian value, it becomes pleasing to look on and an ornament in itself. A comparison of (*a*), (*b*), and (*c*) will show how, without detracting in any way from the purpose of utility, and without adding any outside detail or other device, the elements constituting utility and beauty can all be combined in one design.

The curves in Fig. 2 (*b*) that are substituted for the straight lines in (*a*) must be considered carefully, or their lack of proportion will render the bracket uglier than the simple utilitarian device. The curves characteristic of the classic moldings are used in (*b*), and where necessary they are separated by straight lines in order to give them emphasis, while in (*c*), the curves are Gothic.



(a)

(b)

7

FIG. 3

7. While this principle of design is similar to that of the problem shown in Fig. 1, it partakes of a different character, inasmuch as the surfaces are in different positions and therefore bear the same relation to each other as the bounding surfaces of a solid. Neither are the surfaces subdivided in this case as they are in Fig. 1; they are simply outlined with a pleasing contour. There is an unlimited variety in the combination of curves that can be used in solving this problem, but there should be a definite and harmonious relation between the curves that are used to outline the bracket, the shelf, and the backboard.

Outline design is of importance in its application to vases and vessels of a similar character, and these are usually identical in elevation, no matter from what point they are viewed.

8. Design of a Solid.—The conversion of the simple utilitarian bracket shown in Fig. 2 (*a*) into the ornamental devices shown in (*b*) and (*c*) can be extended to objects of any proportion and size. In the bracket, as said before, it was simply a case of design and an arrangement of surfaces; but in the solid, it becomes a problem of the detailing of surfaces whose interest must be enhanced by subdivision and whose outline is unalterable.

In Fig. 3 (*a*) are shown a plan, front elevation, and end elevation of a low parapet wall interrupted by a post. It is apparent that this is a simple utilitarian construction consisting of a simple geometrical form for the post, from which extend perfectly flat walls with coping and base. The coping is beveled on its under side at an angle of 45°, both on the wall itself and on the post, and the base that extends around the post along the wall is similarly beveled, but no attempt is made to indicate the existence of moldings. Now, if curved lines are substituted for the straight lines of the inclined surfaces just referred to, and these are molded in harmony with rules of classic composition, the utilitarian construction will be converted into an ornamental construction, Fig. 3 (*b*), that is just as suitable to its purpose in every way, but much more pleasing to the eye.

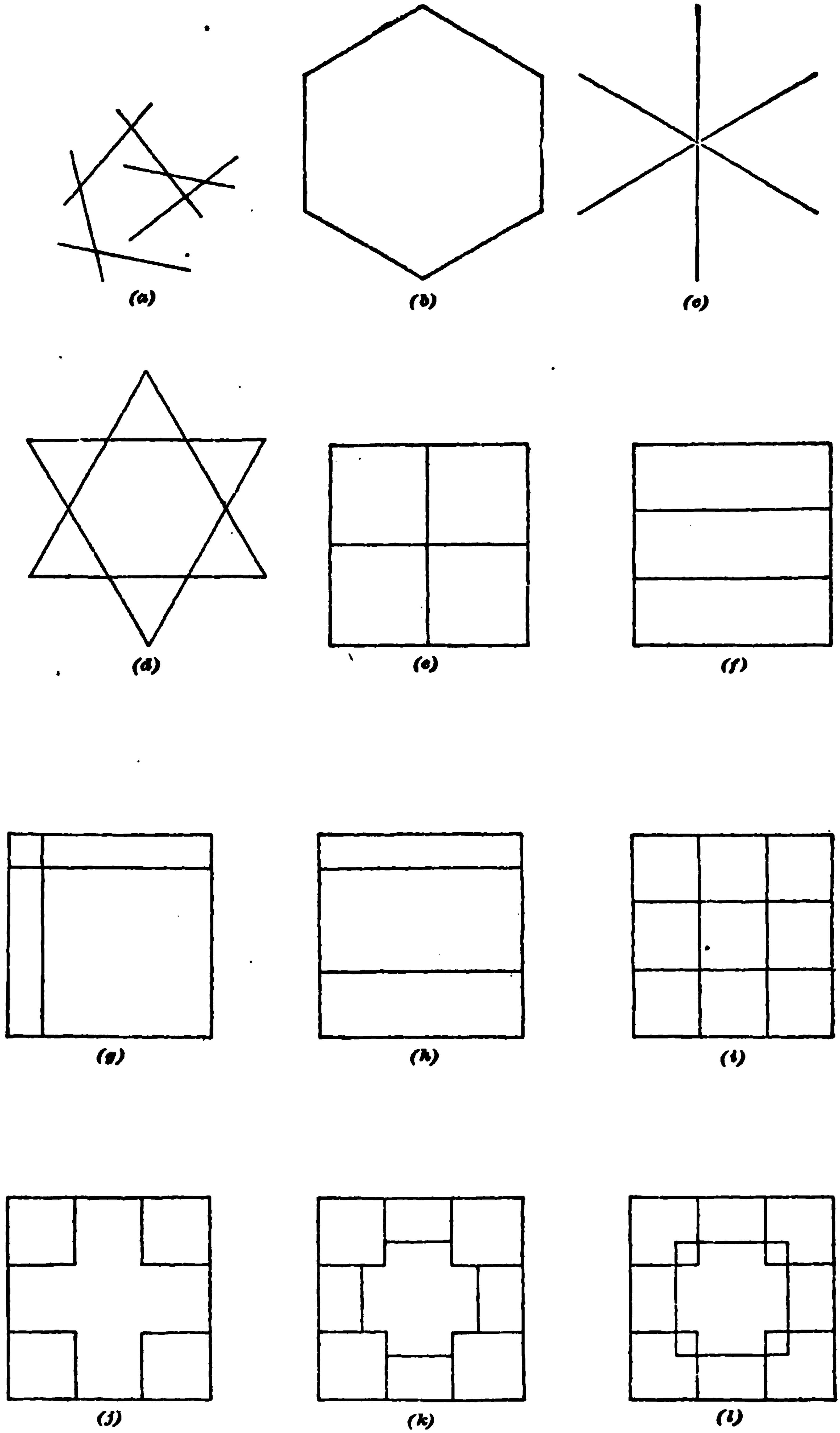


FIG. 4

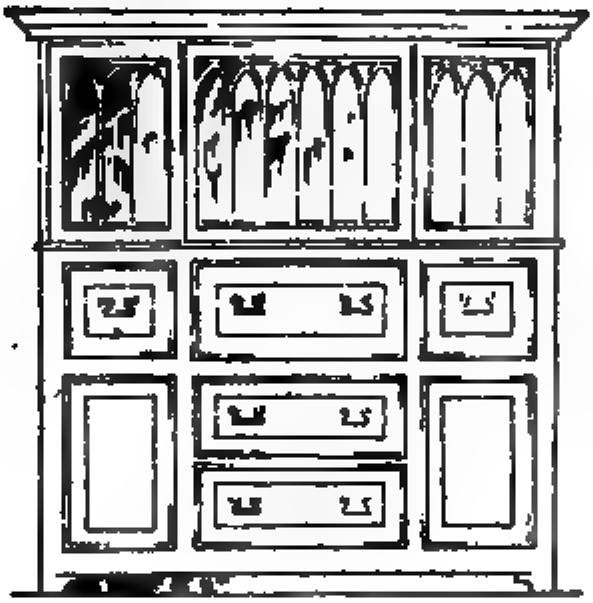
ELEMENTS OF COMPOSITION

9. Composition, whether it be in painting or in architecture, consists in arranging and grouping lines and masses so that in themselves they will present a pleasing relation to one another, regardless of what they represent. In Fig. 4 (*a*) are shown six lines of equal length that bear no relation one to another and are therefore meaningless; but grouped as shown in (*b*) to (*d*), they express a uniform idea from which no one of them could be removed without leaving a feeling of incompleteness. This composite arrangement of lines that forms a complete idea is termed **unity,** inasmuch as the lines no longer form separate elements, but are the units of a design.

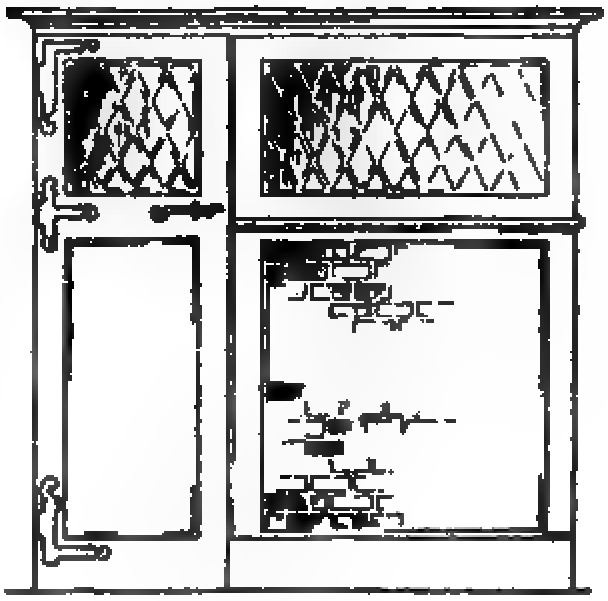
10. Unlimited combinations of lines can be made to express unity in different forms, but some of them will be more pleasing than others. For instance, the six lines just mentioned are united to form a square with four equal interior squares in (*e*), three equal rectangles in (*f*), and two rectangles and two unequal squares in (*g*). Of the last three forms, (*e*) and (*f*) are the least interesting, as they present no variety; and while (*g*) is merely a variation of (*e*), and (*h*) a variation of (*f*), these simple variations serve to render the forms more interesting while still preserving the feeling of unity. By changing the lengths of the lines and introducing more of them, an infinite variety of designs can be produced, all composed of squares and rectangles and all based on one general arrangement.

In (*i*) is shown a checker arrangement of eight lines that is interesting in itself, but becomes more pleasing with the removal of the central square, as shown in (*j*). By replacing the sides of the central square nearer the outside square, the design shown in (*k*) is produced, and this suggests a continuation to the form shown in (*l*).

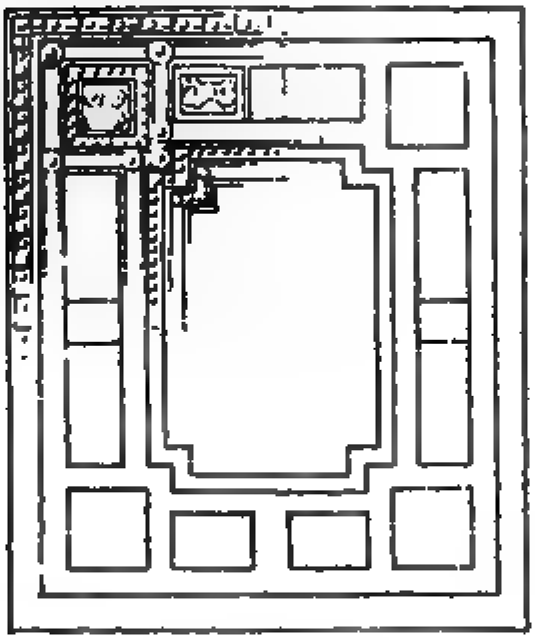
11. The application of this idea architecturally is shown in Fig. 5, where at (*a*), the structural lines of the cabinet are derived from conditions similar to the ones shown in



(a)

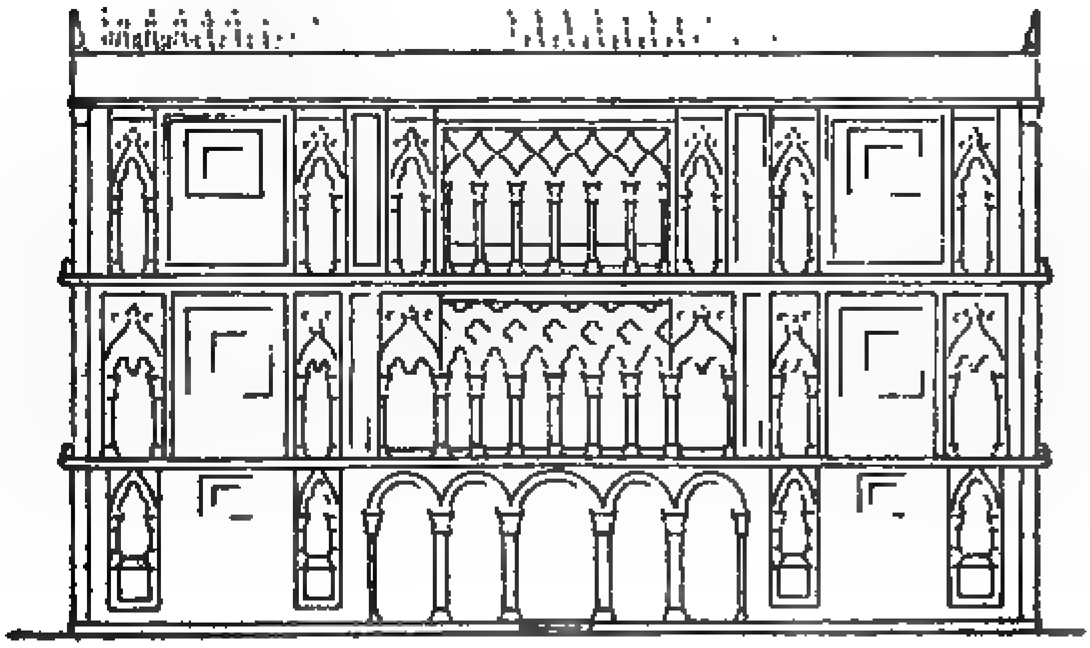


(b)



(c)

(d)



(e)

FIG. 6

looking at the design the eye will not wander from one part to another, but will be arrested by a single central feature or others around it, on which all other features seem to depend. All the elements of a building should then be treated according to their importance, so as to come in a general group, and in order to do this, they must be subdivided so as to become details of the mass.

14. While unity of the mass is essential to all composition, it does not prevent the introduction of many similar subordinate details, each of which may be considered as a minor unit in itself. All the designs shown in Fig. 1 are composed of a number of minor units that are repeated to unite and form the whole pattern. Therefore, repetition is an element of design that can be depended on to lend interest to subordinate parts.

15. Where repetition is thus introduced, the design should be terminated at each end with some important detail, in order to prevent the feeling of **continuity,** or **unlimited repetition,** which is very unsatisfactory in architectural composition. This is prevented in the example shown in Fig. 6 by the tower masses at each end, between which the dormers are repeated, but in the Château Josseln, Fig. 7, there is no terminating mass, and the building consequently has an unfinished appearance, as if something more was to be added.

The only condition wherein continuity is acceptable in an architectural composition is around an interior court where a colonnade can be carried around all four sides, as in Fig. 6, *History of Architecture and Ornament*, Part 4. An interior colonnade should always be included between flanking masses (see Fig. 43, *History of Architecture and Ornament*, Part 4) or around the building as a peristyle, as in the Greek temples.

ALTERNATION

16. Alternation consists in the repetition of two or more details alternately, as in the second story of the Farnese Palace, Fig. 4, *History of Architecture and Orna-*

ment, Part 4, where the pointed pediment and the curved pediment are used alternately over the windows. In alternation, it is important that an odd number of details be used, so that both ends may be alike; otherwise, the feeling of continuity will be even more marked than in simple repetition.

Fig. 6

CONTRAST

17. Contrast consists in the grouping of details that are totally unlike either in form or in size. It is introduced in architectural composition to give prominence to the principal detail, in order to avoid a division of interest, as will be discussed under the heading Grouping.

16

FIG. 7

GROUPING

18. In arranging architectural details to secure the effect of unity, there are three groupings that are entirely satisfactory.

A *single mass* always looks well when surrounded by subordinate details that do not distract the attention from the central feature, as in the Market at Haarlem, Fig. 59, *History of Architecture and Ornament*, Part 4. Other examples of this individuality of mass are to be found in the pyramids of Egypt, the Parthenon at Athens, and the Hôtel des Invalides at Paris.

A group of *two similar masses* is satisfactory if there is nothing inharmonious between them, as can be seen in the elevation of the Cathedral of Notre Dame, Fig. 1, *History of Architecture and Ornament*, Part 3. The two masses must be similar, however, although not necessarily identical. A square tower and a spire or a dome are too unlike to be grouped as a pair in one composition. Beautiful as the tower of the Antwerp Cathedral may be in itself, the entire composition is unsatisfactory, owing to the dissimilarity of the neighboring mass. (See Fig. 29, *History of Architecture and Ornament*, Part 3.)

A group of *three things* can be made to look well in composition, as in the Church du Béguinage, Fig. 58, *History of Architecture and Ornament*, Part 4, if the group does not consist of details equal in importance or identical in form and size. Three minor details can be grouped together, as three windows or three arches, but three domes, three gables, three spires, or three wings in a building, all of practically the same value, cannot be made to harmonize.

19. When three such important details are to be grouped, one of the three must be either emphasized, so as to present a single feature dominating the other two, or subordinated, so as to form a group of two connected by the third. The members of a group of three need not be of exactly the same form, although they should be sufficiently so to asso-

FIG. 8

ciate themselves with the same idea. The towers and the dome of St. Paul's Cathedral, Fig. 8, are unlike in form, but they are all associated as roof details and unite against the sky to establish a principal feature. The dome is attended by two subordinate features—the towers. In the front view of the building, however, the towers become the leading

FIG. 9

features, and they form a group of two with the pedimented portico between, as shown in Fig. 9. It is evident, therefore, that the design of St. Paul's Cathedral presents different problems, according to the point from which it is viewed.

20. Single Mass and Group of Two Masses.—For the purpose of practically demonstrating the foregoing principles, the illustrations shown in Fig. 10 will be considered. In (*a*) is shown a single mass constituting a group of *one*,

(a)

FIG. 10

and in (*b*) there are two masses of unequal importance connected by a detail too insignificant to distract the attention in the slightest degree. The large mass undoubtedly arrests the attention at first, but the smaller one soon unites itself in the idea and there is at once the desired feeling of unity.

In (*c*) is shown a group of two almost identical objects with a connecting detail. Here, however, it will be observed that this connecting detail is of more importance than in the preceding case, and that the masses are more separated. Where the masses are unequal, particularly if only slightly so, it is desirable to bring them close together in order to emphasize this inequality; but where they are intended to be alike, it is well to separate them, so as to make them appear as a group of two and at the same time subdue any slight inequality of detail that might exist in them.

21. Group of Three Masses.—In arranging a group of three masses, the rules to be followed are the same as before, but a satisfactory disposition of the principal and subordinate parts becomes more difficult to accomplish. In Fig. 10 (*d*) is shown a group of three unequal masses, the largest one being in the center and the others arranged on each side. This is the most logical arrangement for such a group, and from a certain point of view, the lesser object is near the observer, the smallest one being in the distance, where its apparent size is decreased, and the contrast between the three masses becomes at once evident. However, suppose that the grouping be studied from the opposite direction as in (*e*). Then the smallest mass is nearest the observer, and the second one in the extreme distance appears about the same in importance as the third. Closer observation proves this to be false, and as a result the composition lacks repose. To obviate this, the grouping should be so arranged that masses *a* and *c* are close together and contrast with each other, and that mass *b* is moved farther away so that it will not become associated with *c*.

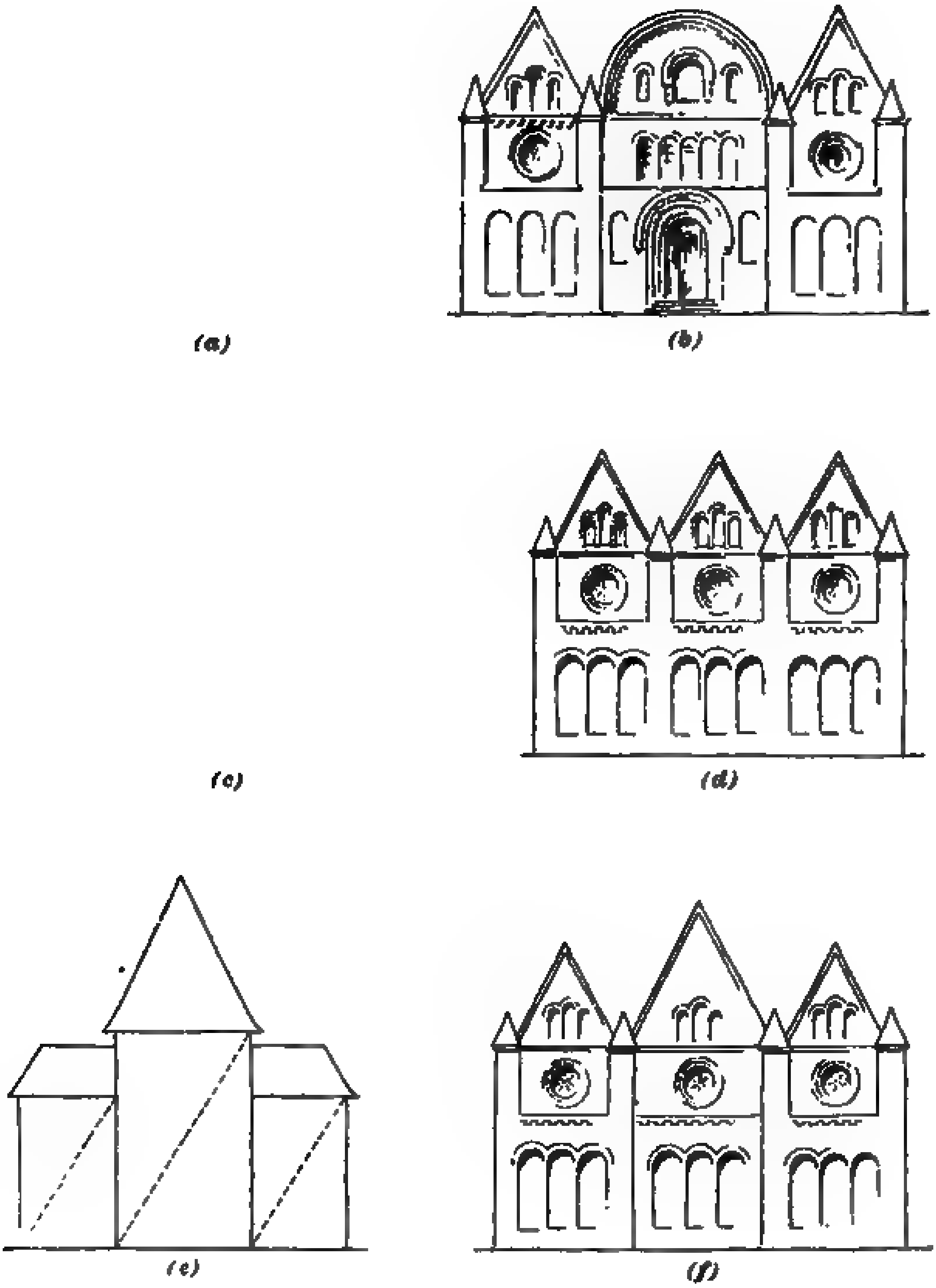


FIG. 11

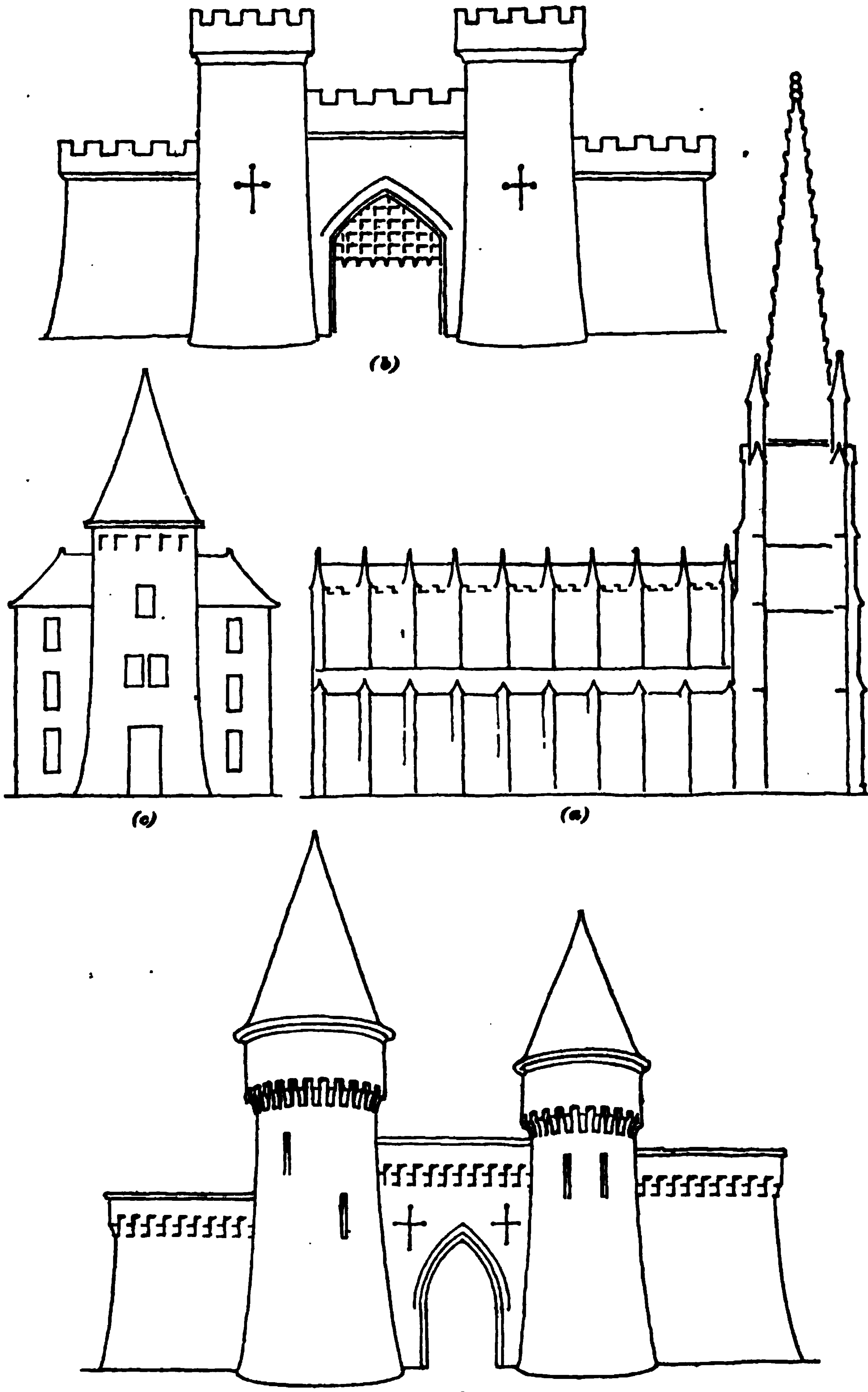


Fig. 12

other two; or, the central mass may be minimized by emphasizing the flanking masses and treating the composition as a group of two. This cannot be done with the two arches just referred to, however, unless they are united under a single arch, as was occasionally done in the Venetian palaces [see Fig. 26 (*a*), *History of Architecture and Ornament*, Part 4].

The three equal, but dissimilar, masses shown in Fig. 11 (*b*) do not harmonize much better than the two shown in (*a*), and if the composition were altered to include three gables, as at (*d*), the design would still be unsatisfactory, as it consists of three equal and similar masses. Therefore, there remains only one of two things to do—either increase the importance of the central mass, as in (*f*), or treat the two outside gables as auxiliary masses, as explained in the next article.

25. Auxiliary Masses.—There are occasions in architectural design when it is hard to decide whether a part of the building is a mass or a principal detail. In the Hôtel des Invalides, Fig. 44, *History of Architecture and Ornament*, Part 4, there is no doubt about the dome being the principal mass, but the side wings seem to belong to mass also, and can scarcely be called details. Therefore, the wings become **auxiliary masses** [see Fig. 11 (*e*)], and are necessary to complete and emphasize the importance of the main mass itself. A similar composition exists in St. George's Chapel, Fig. 82, *History of Architecture and Ornament*, Part 2.

An auxiliary mass may be symmetrical or otherwise, as the case may require. It may form part of a composition consisting of one mass and an auxiliary, as in Trinity Church, New York, Fig. 12 (*a*); it may be duplicated each side of a central detail, as in the Hôtel des Invalides already referred to; or it may be attached to each of the masses in a composition of two, as shown in Fig. 12 (*b*). The auxiliary mass need not necessarily be low, as tall auxiliaries, Fig. 12 (*c*), are quite as common.

The auxiliaries in a triple group should be symmetrical when the triple masses are symmetrical; but when the out-

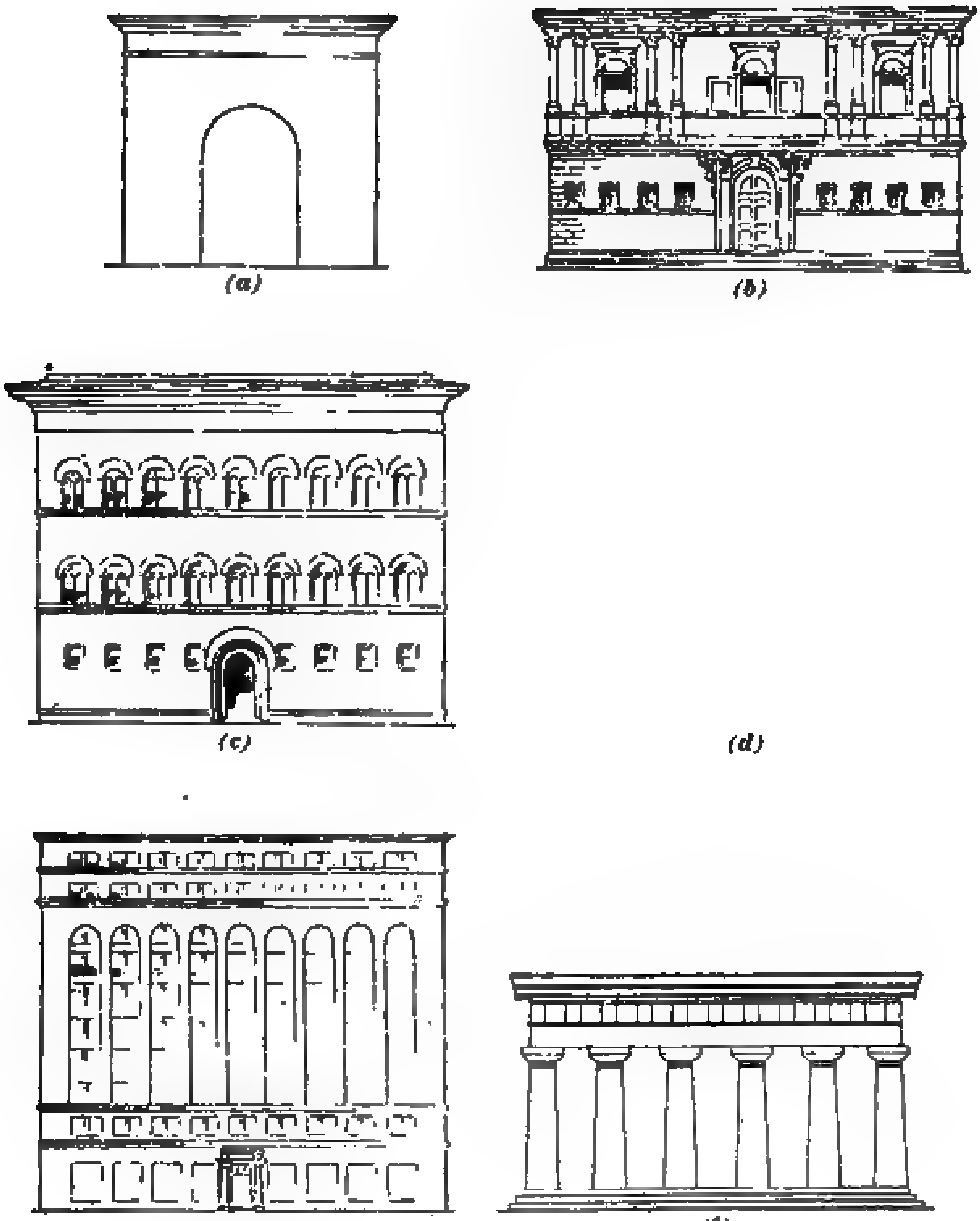


Fig. 18

side masses of the triple are unsymmetrical, or unequal, the auxiliaries should be unsymmetrical also. Generally speaking, the smaller or less pretentious auxiliary should be placed against the larger general mass, and the larger of the auxiliaries should be similarly placed with regard to the smallest of the triple masses, as in Fig. 12 (*d*).

In treating parts of a composition as auxiliary masses, it should be borne in mind that they must be smaller than the principal parts of the masses to which they are attached; also, they should be so different in treatment as to leave no room for doubt as to whether they are principal parts or auxiliary parts.

USE OF MOLDINGS

26. Moldings are used in architectural design to subdivide masses by means of horizontal bands. They are of varying forms, but their general purpose, namely, the production of horizontal lines of shadow, is the same in all cases. The essential difference in appearance between classic and Gothic buildings is due to the difference in the direction of their prevailing lines.

In the subdivision of buildings by moldings, the same rules apply as in the grouping of masses. One surface looks well alone. Two equal surfaces also look well, but they must be treated differently in order to secure variety of effect with equality of value in the two members. Three surfaces always look well together, but the middle one should as a rule be the largest.

27. When one surface is exposed by itself, a wide, strong cornice should surmount it, in order to emphasize its finish at the top, and one prominent detail should always relieve the face, as in the triumphal arch, Fig. 13 (*a*), and the Strozzi Palace, Fig. 13 (*c*). When two subdivisions are used, the lower one had better be treated with heavy constructions and small window openings, and the upper division with light pilasters and arched openings, as in (*b*).

With a subdivision into three parts, the problem is a very simple one. Three *equal* parts require a simple treatment in

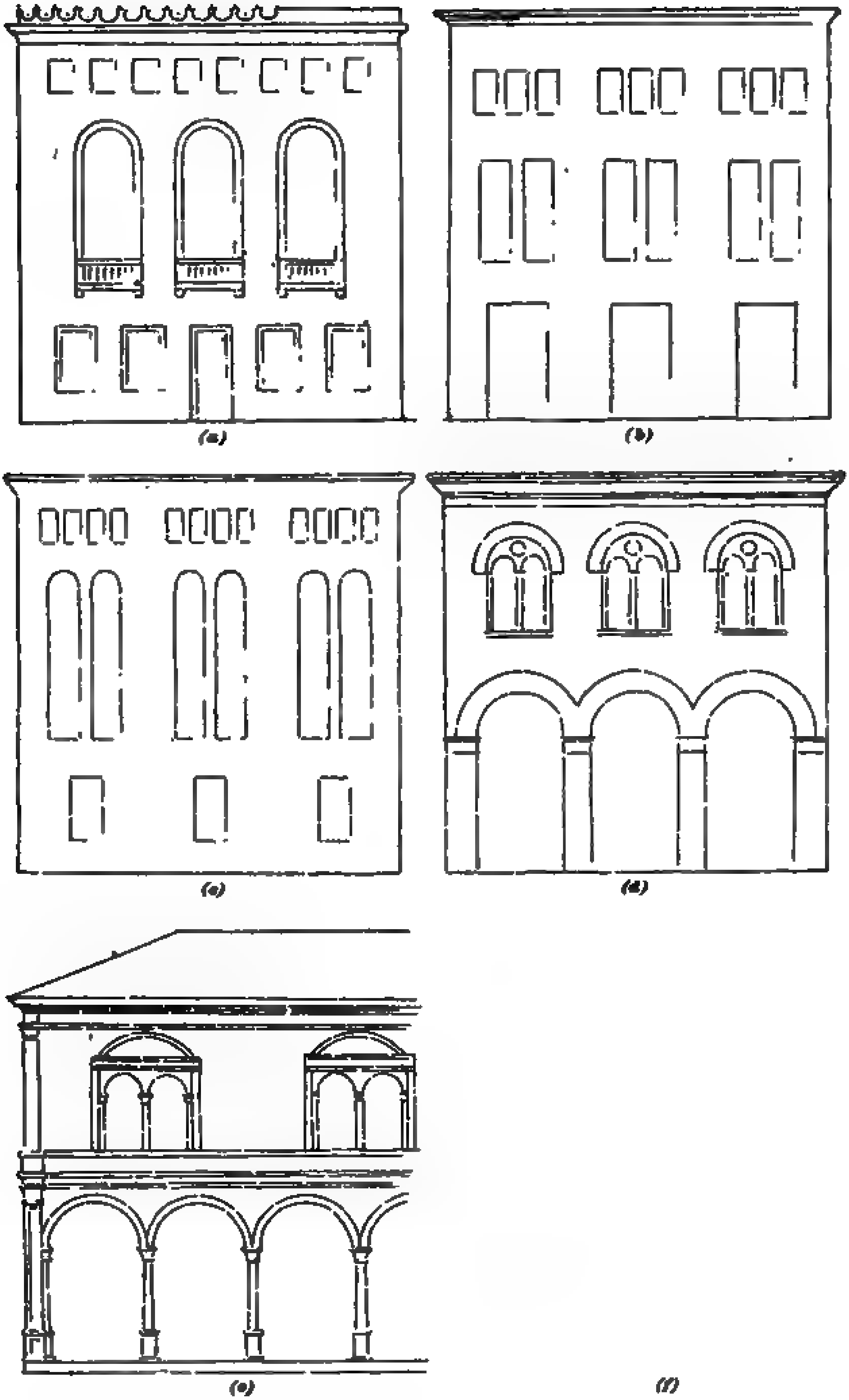


FIG. 14

ARCHITECTURAL PROPORTION

METHODS OF PROPORTIONING MASSES

29. Architectural proportion is not a ratio between one dimension and another, as of length to breadth or of breadth to height, but is rather a ratio of mass to mass, either in surface or in solid. While it is a generally accepted theory that a tall, narrow building should possess tall, narrow windows, as is exemplified in Gothic architecture, it does not follow that a low, broad building should have wide, squatty windows. It is very important, therefore, to consider some rule that may be adopted to determine this relation of proportion between mass and detail.

That such a proportion existed in ancient architecture is evident, but there is nothing to prove that this proportion was a mathematical one. However, it is necessary to have a point at which to begin to study a complex subject; therefore a start will be made with architectural proportion from a mathematical basis, even if by so doing it will only be possible to learn what to avoid.

30. The Greek temples were broad, low buildings, with short columns, low pediments, and a stylobate of about three steps. The columns were from four to six times their diameter in height, and a feeling of horizontal lines predominated in the composition. This is clearly shown in the façade of the Parthenon, Fig. 15 (*a*).

The Roman columns, however, were designed to be from eight to ten diameters in height, and, consequently, not only a steeper pediment is found, but also an increased elevation of the building above the ground. The façade of the temple of Fortuna Virilis at Rome, Fig. 15 (*b*), shows the columns resting on a high podium, instead of on a low stylobate, and

the pediment inclined at an angle of about 27° instead of 11°, as in the Parthenon.

Later, when Romanesque architecture was fully developed from its classic ancestor, we find that the pediment has become a gable and all the other structural lines have assumed a perpendicular feeling, as in Fig. 15 (*c*), directly in contrast to the classic feeling that characterized Grecian architecture.

Finally, the perfected Gothic style succeeded the Romanesque and exceeded it in the perpendicular tendency of its detail, and at the same time the spire, Fig. 15 (*d*), is found superseding the pointed gable in the effort to emphasize the vertical feeling in design.

Why, then, are two structures so entirely unlike, so diametrically opposite, as the Grecian temples and the Gothic cathedral, equally admired? The only answer to this question is that the buildings of each particular period were carefully proportioned to suit the requirements of each system of design. It is not possible to lay down a set of rules that will determine the proper relation of surface to surface in every case of design, but an approximate rule can be given, and with this as a foundation and good taste as an alternative, satisfactory results can be approached in nearly every case.

31. In applying any rule of this character, it must be borne in mind that there are certain details of a building that cannot in themselves be compared, although their arrangement and emplacement may. For instance, a column, being a solid member of support, cannot be compared directly with a window, because the window is a void member over which something must be supported. A lintel cannot be compared with the mass of the entire structure, because it relates only in length and depth to the opening it spans. Chimneys, turrets, etc. are appendages that may or may not form a prominent detail of the building, and are therefore exempt from any rules governing proportion of fixed masses.

It must also be borne in mind that if it were possible to design all parts of all buildings according to a fixed mathe-

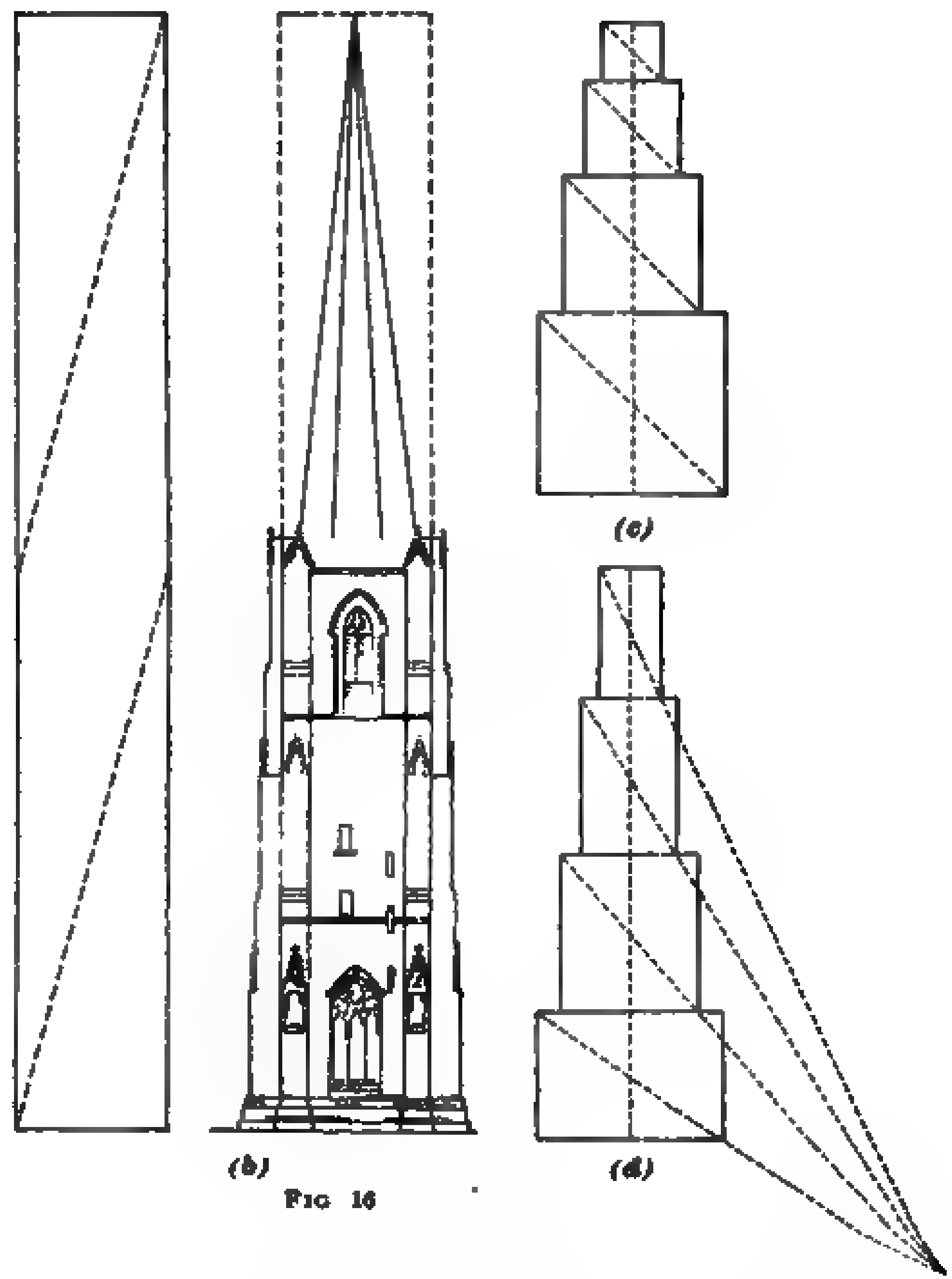


Fig 16

matical basis, there would be no variety or originality in design from one generation to another.

32. The drawing of diagonal lines parallel to each other will lead to a proportioning of some details that, when modified somewhat according to conditions and taste in each case, will produce admirable results. In Fig. 16 (*a*) is shown the front elevation of a Gothic church.

The towers constitute a group of two masses connected by a minor detail. The parallel diagonals determine the proportion of these masses to each other and at once give a general relation to start with, even if this relation cannot be strictly adhered to throughout. This proportion exists in the façade of the Cathedral of Notre Dame, Fig. 1, *History of Architecture and Ornament*, Part 3. The same principle can be applied to a low composition, as is shown in Fig. 11 (*e*), where a mass and two auxiliaries are so proportioned.

The proportions of a spire in a Gothic church can be determined by drawing a diagonal parallel to the diagonal of the construction, as in Fig. 16 (*b*). But here is where the treacherous side of the system begins to show itself, as parallel diagonals will not give such satisfactory vertical proportions of mass as they will of horizontal ones. However, this discrepancy is more a matter of perspective than of exception to the rule, although comparative contrasts have also something to do with it.

In (*c*) is shown a group of three details superimposed in a tower composition. Proportioned on the diagonal, these details have a low, flat appearance, thereby determining at once the inapplicability of this rule for this purpose. This flat appearance is exaggerated when the series is observed in perspective, as the projection of each detail below the other hides some of the one above. The members in a vertical composition should therefore be *stilted* and the diagonals drawn so as to radiate from a given point, as in (*d*). Even after deciding the general proportions in this manner, it is likely to be subsequently found that general appearances require some rearrangement in order to satisfy the

In Fig. 14 (*b*), the grouping of the windows causes the composition to assume a series of both vertical and horizontal bands, the openings increasing in area from the lower story upwards, while the superimposed masonry is proportionately less. The same principle is carried out in (*c*), but with a greater variety of opening, so as to divide the façade into three equal bands. For a two-story structure, a symmetrical grouping such as shown in (*d*) gives satisfactory results, but should be varied if the building is a long

Fig. 18

one so as to prevent monotony. The grouping of the windows over a pair of openings in the lower story, as shown in (*e*), presents greater areas of wall in the second story, and while this makes a pleasing arrangement generally speaking, care must be exercised to avoid the appearance of a building set up on stilts or props. The union of two stories in a one-story composition, as in (*f*), is frequently resorted to, and here the structural conditions are deliberately misrepresented to produce effect.

GROUPING OF PRINCIPAL DETAILS

34. It is not always easy to distinguish whether a certain detail is a principal mass or a subordinate mass, and where any doubt is likely to exist as to this identity, the part

Fig. 19

in question should be emphasized or subdued in order to make it conform to the part assigned to it in the general composition. **Subordinate masses** are those masses which can be entirely removed from a composition without in any way destroying the completeness of the main composition.

The château of Chenonceau, Fig. 18, presents in composition a single mass with five principal details, or subordinate masses. These are the three dormer windows and the two corner turrets. Remove these, and the principal mass would remain the same. This is due to the fact that the principal details are so subordinate to the principal mass that their presence does not detract from its value in any way.

35. Grouping of a Simple Mass.—For general practice, take, to begin with, a simple mass that is rectangular and symmetrical, with a gable roof extending from end to end, as shown in Fig. 19 (*a*). The long side is to be relieved by a subordinate mass that will be introduced as a center gable, as in (*b*). This gable, however, is so long, and so similar to the main gable that it detracts from the importance of the principal mass and claims recognition as a principal part itself. Therefore, it must be subdued so as not to be so conspicuous. It may be compelled to show its subordination as a large dormer, as in (*c*), it being evident that a dormer must be subordinate to a projecting wing, or the gable can be lowered until it appears as in (*d*); or, the form of the roof can be changed to contrast it with the main gable, as in (*e*). The form of the body can also be altered as in (*f*), and thus, simply by the addition of an octagonal turret, a rectangular rustic cottage can be rescued from the ranks of the commonplace and classified in the lists with the picturesque and beautiful. As a matter of fact, this is exactly what was done, this illustration being taken from an original one of a little French cottage in Angers.

36. A single turret placed unsymmetrically is a very satisfactory treatment in some compositions, and has been used in many instances in both medieval and modern architecture. The entrance to the Hotel de Ville, Bourges, France, Fig. 20, presents a most satisfactory composition, and yet nearly every detail is unsymmetrically placed. The openings are not in the center of the pavilion, and the unsymmetrically placed turret was an absolute necessity in order to balance the composition.

37. Grouping of Two Details.—In the grouping of two principal details, the same rules apply as for the grouping of masses, except that there need be no connecting link between the details, as the mass itself on which they are placed unites them into one composition.

FIG. 20

The two gables shown in Fig. 21 are simple details in the composition and form an inferior group of two. They are unequal in size and different in detail, but they are near

enough alike to present the impression that one is a primary detail and the other a secondary detail.

38. Grouping of Three Details.—In grouping three principal details, great care must be exercised. Details that are exactly similar are likely to lead to unpleasant impressions. Three dormers, three bays, or three wings may be made to appear all right if they do not interfere with, or tend to detract from, the mass itself. It is always best, however, to have one of the three larger than the other two, as the monotony otherwise likely to exist can then be overcome. The three dormers on the château of Chenonceau, Fig. 18, are similar details, but the emphasis given

Fig. 21

the center one relieves the group from monotony. Three similar gables equal in effect must be entirely subordinate to the mass, as a uniform arrangement of this character is a difficult and risky one to undertake.

In a group of three principal details, the effect may be obtained not by adding anything to the mass, but by dividing the mass into subordinate parts, as shown in Fig. 17 (*g*). The central part can to advantage be made somewhat larger than the extremes, and thus relieve the composition of all feeling of monotony. This treatment is frequently found in church architecture, where the façade is divided into bays by means of buttresses, as in Fig. 17 (*g*).

39. Grouping of More Than Three Details.—A group of more than three details can be arranged if they are alike and of one purpose, as, for example, the gable dormers in the Château de Blois, Fig. 6. Where the number of these details is uneven, it is better to emphasize the central one by making it somewhat larger than the others, or treating it in a different manner. With an even number of details no such emphasis is necessary, but effort should be made to avoid a feeling of continuity.

GROUPING OF MINOR DETAILS

40. The grouping of such minor details as doors, windows, pinnacles, turrets, dormers, etc. is a matter of utmost importance in architectural composition, being second only to the masses themselves. An unavoidable objectionable arrangement of masses may often be compensated for by a skilful handling of the **minor details.** Minor details, while governed largely by the same rules as principal masses, can be handled more freely and altered to suit special conditions more readily than can the masses themselves.

Minor details may be divided into two classes: *voids* and *solids*, the former consisting of doors, windows, intercolumniation, etc., and the latter of piers, columns, and wall surfaces. It is essential that one should be fully cognizant of the effect produced by a detail, as a number of windows may be made to appear in them as a series of openings or to give the appearance of a series of piers, according to the method of treatment, as shown in Fig. 17 (*g*) and (*h*).

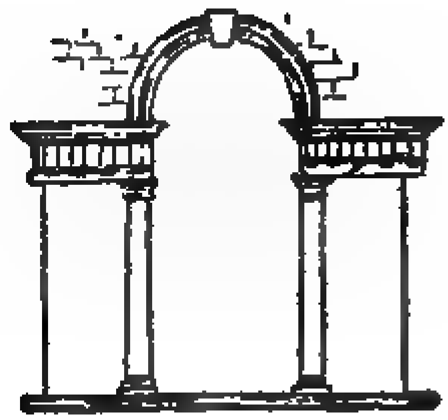
41. Windows may be grouped in pairs or in triplets, as shown in Fig. 22 (*a*) and (*b*); but where more than three are included in one group, they should be included under one dripstone, as in (*c*), or within one panel, in order to preserve the idea of unity. In triple windows, the middle one should always be slightly larger than the other two, as in (*e*); otherwise, it will look smaller. Three openings exactly alike and side by side will always produce an effect

(a)

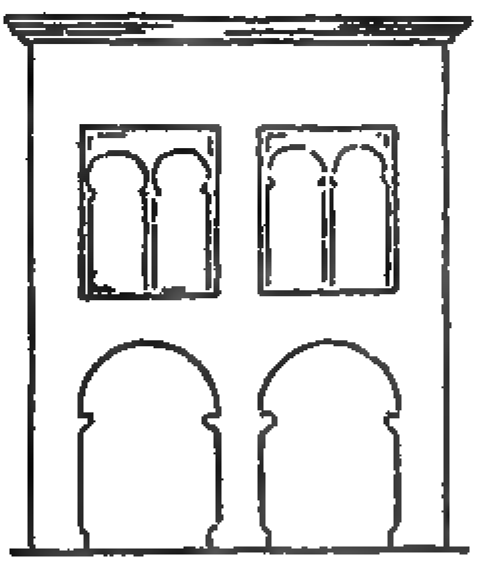
(b)

(c)

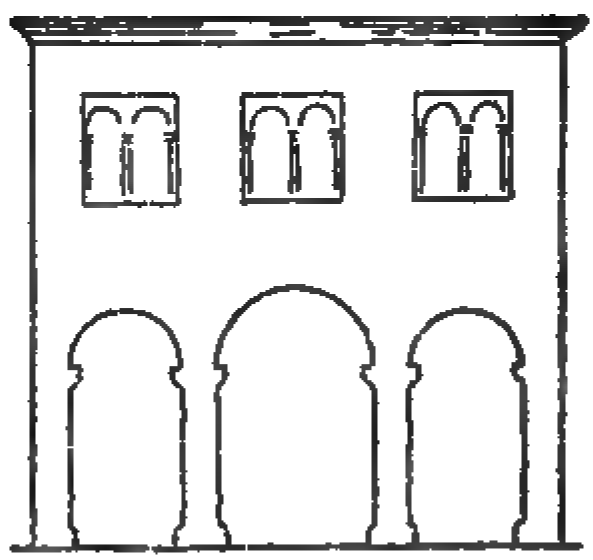
(e)



(f)



(g)



(h)

FIG. 22

of littleness in the middle opening, unless treated as one opening by means of mullions, as in (*d*).

Doors, as well as windows, may be grouped in pairs or in triplets; or, considered as openings, they may be grouped with windows, either symmetrically or unsymmetrically. The door and window arrangement shown in Fig. 5 (*b*) is quite common, both in the symmetrical and in the unsymmetrical arrangement.

42. A very pleasing arrangement of three symmetrical openings is shown in Fig. 22 (*f*). This arrangement is found in the entrance to the Villa Medici, Fig. 19, *History of Architecture and Ornament*, Part 4, and may be considered as analogous to a mass with two auxiliary masses. Almost identical with this in the character of its outline is the Tomb of Napoleon, Fig. 12, or St. Peter's at Rome, Fig. 44, *History of Architecture and Ornament*, Part 4.

The arrangement of the openings in the general mass is a matter of great importance, as on it all designs depend largely for effect. A combination of three openings in the second story over three openings in the first story gives a pleasing effect, and so does a similar arrangement of either two or four, although in the latter case there is a danger of a dual effect unless some special details are introduced to insure that the whole composition will be considered as a single mass. In repeating these arrangements, they should not be used in pairs, as in Fig. 22 (*g*), nor in triplets, unless the center is emphasized as in Fig. 22 (*h*).

In a group of two masses, the windows in the connecting mass should be uneven in number, so that the central opening may suggest an axial line on which the composition may be divided. The purpose of the connecting link is self-evident, and it is undesirable to have it identified entirely with the two masses at the ends. When a single mass is central and two auxiliary masses extend on each side, the openings should be even, so as to prevent any possibility of an imaginary axis through the auxiliaries, causing them to be considered as separate masses.

CLASSIC PROPORTIONS

43. As has already been stated in *History of Architecture and Ornament*, Part 1, Arts. **129** to **132**, the details of classic design were based on a system of proportion established in the architectural orders. These classic proportions were made public during the Renaissance period by means of a series of papers written by different authors, the best known of these series being that of Vignola, published in 1563. The proportions of these classic orders must be known by the modern designer, as they are used in all constructions in which classic details are adopted. The system herein set forth varies somewhat from that of Vignola, but it is much simpler and therefore far better suited to modern practice, where the standard of measurement is based on the English foot or the French meter and their subdivisions into inches and centimeters.

THE ORDERS

44. In classic architecture, the several varieties of column and entablature were called **orders.** Each order, Fig. 23 (*a*), comprises a *column* with base, shaft, and capital, (with or without a *pedestal*, with its base, die, and cap), which is crowned by an *entablature*, consisting of an architrave, frieze, and cornice. The entablature is generally about one-fourth as high as the column, and the pedestal about one-third.

45. The principal member of the cornice is the *corona*, which is shown in Fig. 23 (*h*). Above the corona, the cornice is regularly terminated by a member originally designed to serve as a gutter to receive the water running down the roof. It generally consists of a large cyma recta. though the ovolo and the cavetto are often used. It is

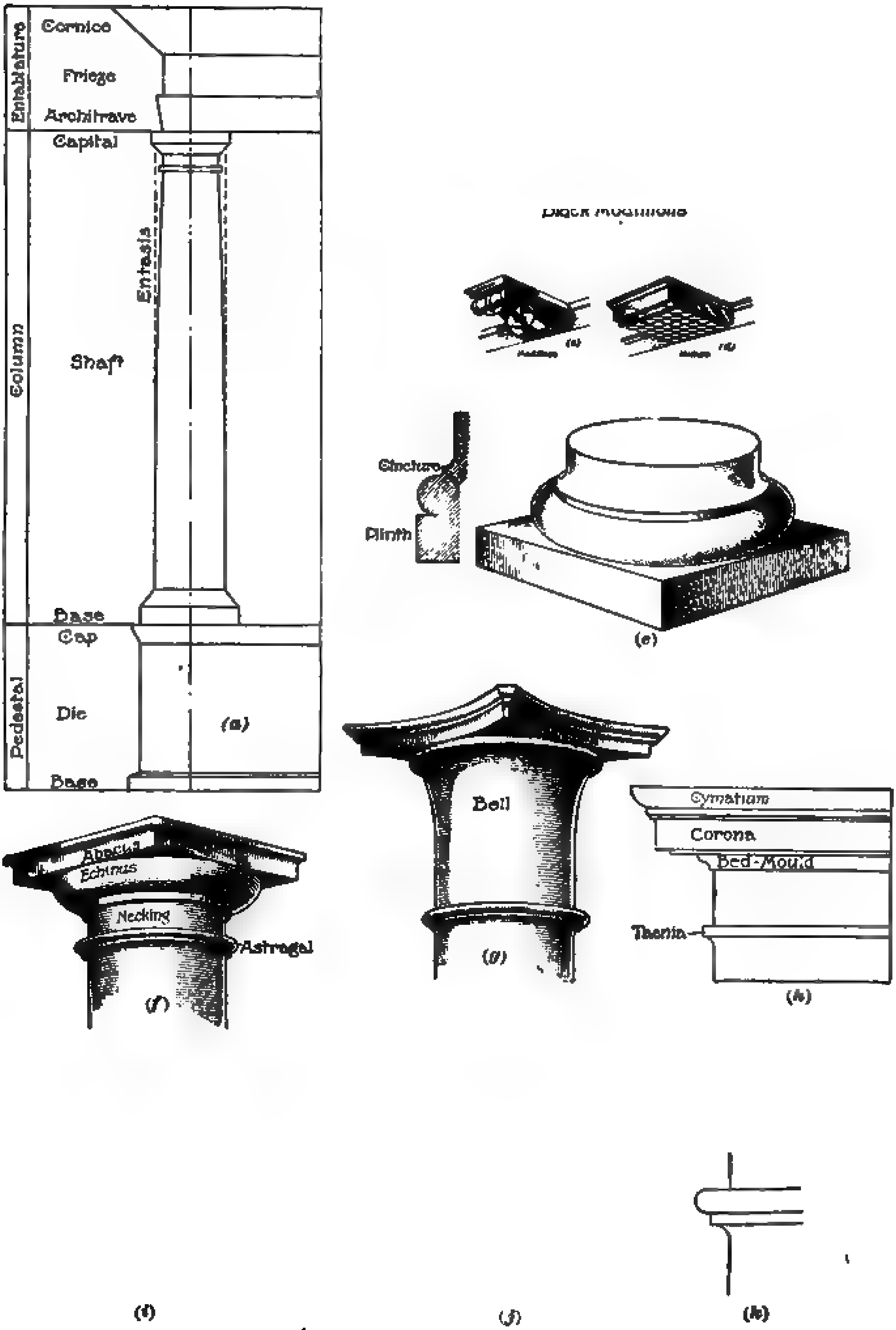

Cornice
Frieze
Architrave
Entablature
Capital
Entasis
Shaft
Column
Base
Cap
Die
Pedestal
Base
(a)
Block Modillions
Cincture
Plinth
(e)
Abacus
Echinus
Necking
Astragal
(f)
Bell
(g)
Cymatium
Corona
Bed-Mould
Taenia
(h)
(i)
(j)
(k)

FIG. 23

sometimes called the *cymatium*, no matter what its shape may be.

The corona is supported by a molding or a group of moldings, called the *bed mold*. A row of brackets, termed *blocks*, Fig. 23 (*b*), *modillions* (*c*), or *mutules* (*d*), according to their shape, resting on the bed mold and supporting the soffit of the corona, is often added. At the top of the architrave is a projecting molding that, when square, is called a *tænia*, Fig. 23 (*h*), and the face of the architrave is often broken up into two or three bands, or fasciæ, as shown in (*i*) and (*j*).

46. The abacus of the capital also has a sort of bed mold beneath it. This mold, when convex, is called an *echinus*, Fig. 23 (*f*), from the sea shell, which it resembles in shape. The little frieze below it is called the *necking*. But if the bed mold under the abacus is concave, it dies into the necking like a large congé, and the two together constitute the *bell* of the capital, as in (*g*). The abacus is square in plan, but the echinus, or the bell below it, is round, like the column.

At the top of the shaft is a member called the *astragal* (*f*), consisting of a bead, fillet, and congé. It has a flat surface on top, as wide as the projection of the congé, as in (*k*). At the bottom of the shaft is another congé, and below this is a broad fillet called the *cincture*, as in (*e*). The base generally has, below the base moldings, a plain member called the *plinth*, which is square in plan like the abacus.

47. The shaft diminishes as it rises, as shown in Fig. 23 (*a*), the upper diameter being only five-sixths of the lower, and the outline is not straight, but curved. This curve, which is called the *entasis*, or bending, as of a bow, generally begins one-third of the way up, the lower third being cylindrical. The entasis is not to be confounded with the *diminution*, which is generally one-sixth, the upper diameter being five-sixths of the lower.

Generally, the pedestal also has a corona or cap and bed mold, but no gutter, above the die, and a base molding and plinth below it, as shown in (*a*).

48. In the choice and use of moldings, the tastes and fashions of the Greeks and Romans were quite contrary to those of their successors in the middle ages. The ancients preferred to use vertical and horizontal surfaces at right angles to each other, and seldom used an oblique line, or an acute or obtuse angle, as the Gothic architects did. They also preferred the cyma reversa, seldom employing the cyma recta, which in the middle ages was rather the favorite. Moreover, as has been said, the Gothic architects, in decorating a corner or edge, often cut it away to get a molding, but the ancients raised the molding above the plane of the surface to which it was applied. In the composition and sequence of moldings also, the classical architects generally avoided repetition, alternating large and small, plain and curved, convex and concave. The convex and concave profiles seldom describe an arc of more than 180°, and except in the case of the beak molding and of the bead, moldings are always separated by fillets. When a molding is enriched, it is generally by carving ornamental forms upon it that resemble its own profile, as in Fig. 57, *History of Architecture and Ornament*, Part 1. The Greeks frequently employed elliptical and hyperbolic profiles, while the Romans generally used arcs of circles.

49. Among the Greeks, the form shown in Fig. 41 (*a*), *History of Architecture and Ornament*, Part 1, was used by the Doric race, which inhabited Greece itself and had colonies in Sicily and Italy. This form was much unlike that used by the Ionic race, which inhabited the western coast of Asia Minor, and whose art was greatly influenced by that of Assyria and Persia. The Romans modified the *Ionic* and *Doric* styles, and elaborated the Corinthian order by the introduction of modillions in the cornice, as shown at *B*, *C*, and *D*, Fig. 88, *History of Architecture and Ornament*, Part 1. They also used a simpler Doric, called the *Tuscan A*, and a cross between the Corinthian and the Ionic, called the *Composite E*. These are the **five orders**. The ancient examples vary much among themselves and differ in different places.

VIGNOLA'S ORDERS—PLATE I

50. Plate I shows the proportions of the orders according to Vignola, in terms of the lower diameter of the columns. These vary in height from seven diameters to ten.

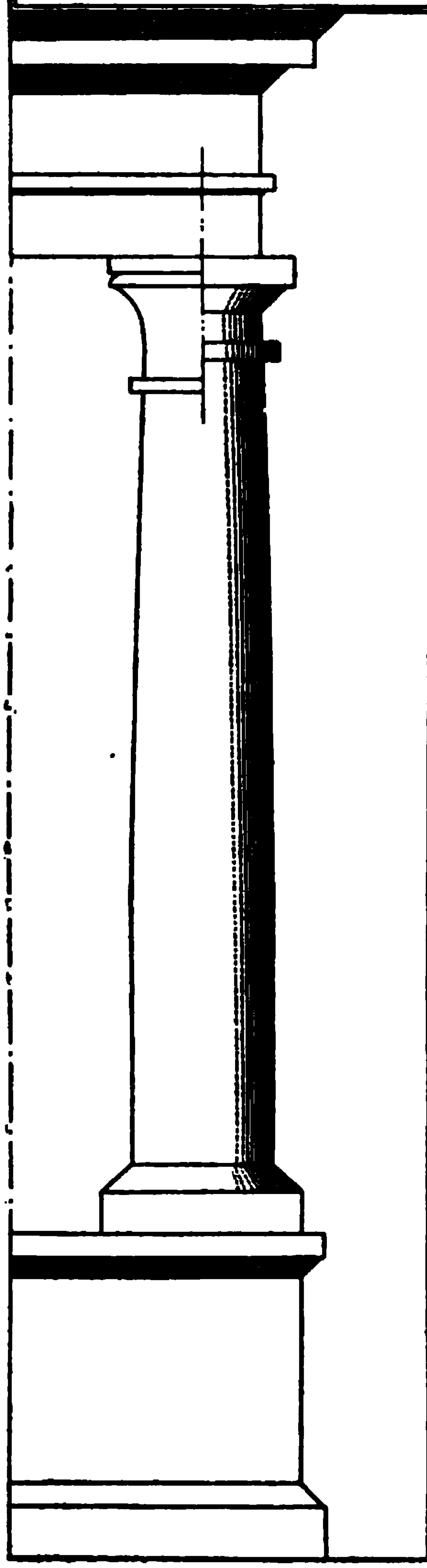
The entablature in all of them is ordinarily one-fourth the height of the column, but it is sometimes made as small as one-fifth. The projection of the cornice is the same as its height, except in the Doric order, where it is greater. The lower band of the architrave is made to come in line with the upper face of the shaft.

But it is only when seen in elevation that these relations obtain. When seen in perspective, as is generally the case, the cornice appears much larger, in proportion, and the frieze and architrave, being foreshortened, much smaller, and the architrave appears to overhang the shaft [see Fig. 25 (*a*)].

In the Greek orders, the column is from five to ten diameters in height and the entablature always about two diameters. In the Greek orders, accordingly, the taller the column, the lighter the entablature, relatively; but in the Roman orders, the taller the column, the heavier the entablature, actually. It follows that the weight of the Greek entablature is proportioned to the diameter of the column, irrespective of its height; of the Roman to the height of the column, regardless of its diameter. The Romans put the least weight on the shortest and strongest supports. The Greek system shows more regard for principles of construction; the Roman for principles of decorative composition.

Vignola used *half* of the lower diameter of the column as his unit of measure, or **module.** This he divided into twelve **parts** for the Tuscan and Doric orders, and into eighteen parts, called **minutes,** for the others, and he gives all the dimensions, both of the larger members and of the moldings, in terms of *modules*, and *parts*, or *minutes*, sometimes using even the quarter minute, or one one-hundred-and-forty-fourth of a diameter. But it is equally practicable

COMPARISON O



TYPE OF ORDER	NAMES OF FEATURES				GREEK DORIC		TUSC
	ENTABLATURE	1/4 to 1/5	CORNICE	CYMATIUM CORONA BED MOULD	2	1/2	1¾
			FRIEZE			3/4	
			ARCHITRAVE	TÆNIA		3/4	
	COLUMN	1	CAPITAL	ABACUS ECHINUS NECKING	4-6	1/2	7
			SHAFT	ASTRAGAL CINCTURE			
			BASE	BASE MOULD PLINTH		NONE	
	PEDESTAL	1/3 ±	CAP	CORONA BED MOULDING	NO PEDESTAL BUT THREE STEPS THE STYLOBATE		THE
			DIE				
			BASE	BASE MOULD PLINTH			THE

PLA

F THE ORDERS

N	DORIC		IONIC		CORINTHIAN COMPOSITE		PERSPECTIVE VIEW
/4	2	3/4	2¼	7/8	2½	1	
/2		3/4		6/8		3/4	
/2		1/2		5/8		3/4	
/2	8	1/2	9	1/3 (1/2)	10	7/6	FROM WITHOUT
6		7		8		8⅓	
/2		1/2		1/2		1/2	

CAP IS ONE NINTH THE HEIGHT OF THE PEDESTAL

PEDESTAL 1/3
[VIGNOLA]

FROM WITHIN

ASE IS TWO NINTHS THE HEIGHT OF THE PEDESTAL

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and more convenient to use the whole diameter as a unit of measure, dividing it only into fourths and sixths, and occasionally using an eighth or a twelfth.

51. In Plates III, V, VI, VIII, X, and XII the first column on the left shows the vertical dimensions as given in Plate I. In the second column, these divisions are subdivided into equal parts, the third column giving a further division of the dimensions thus obtained. Most of these dimensions can be stated in terms of sixths or fourths of the diameter, as appears in the tables. This analysis does not reach the smaller details, the shape and size of which must be learned by observation. Indeed, all these forms should be made so familiar that they can be drawn accurately from memory, these arithmetical relations being used only to test the accuracy of the result, or to discover how much the proportions adopted in any given case differ from the regular type. *Vignola's orders are to be regarded only as an admirable standard that may be safely adopted when there is no occasion to do anything else,* and may be departed from and varied whenever there is any reason for doing so. Vignola himself so regarded

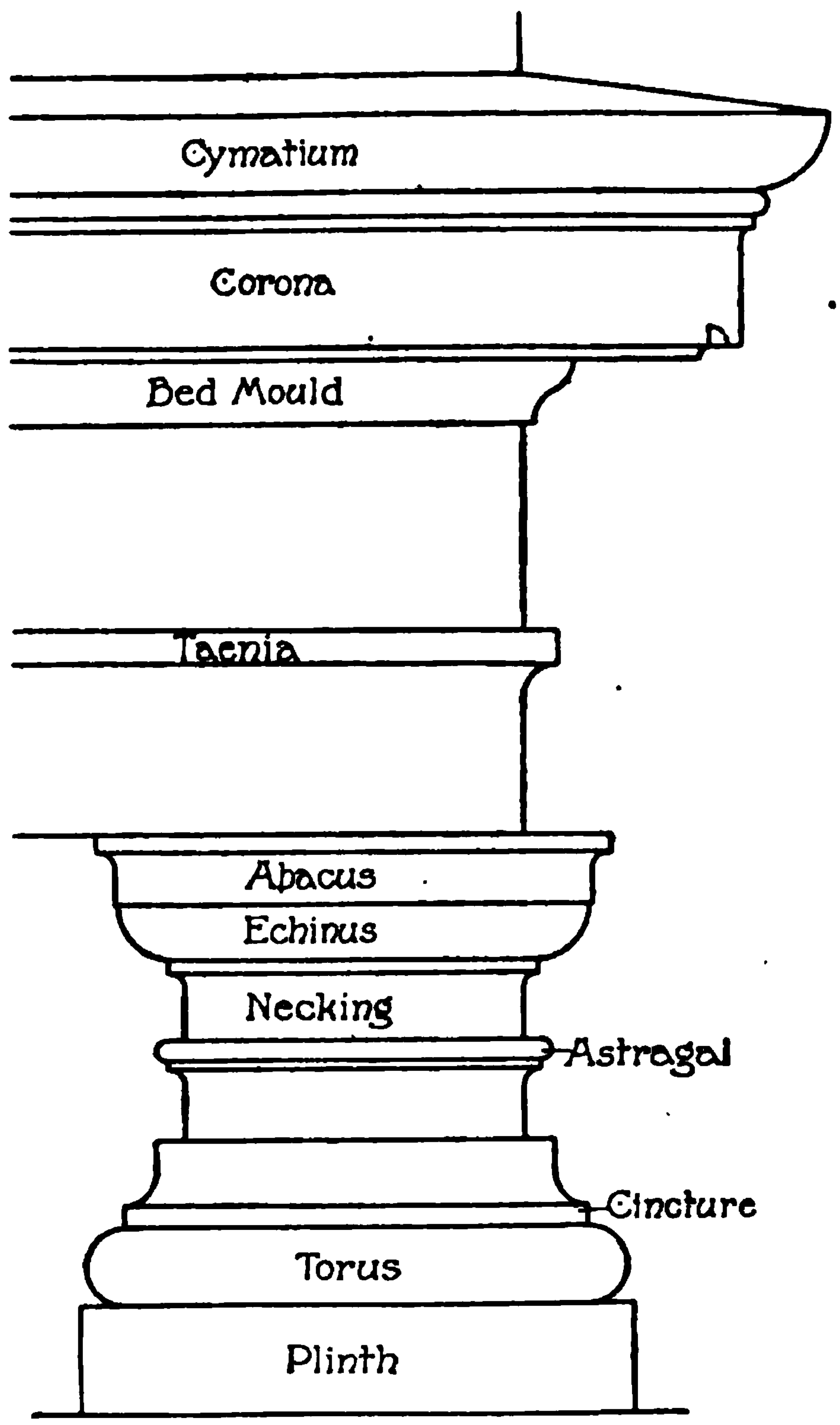


FIG. 24

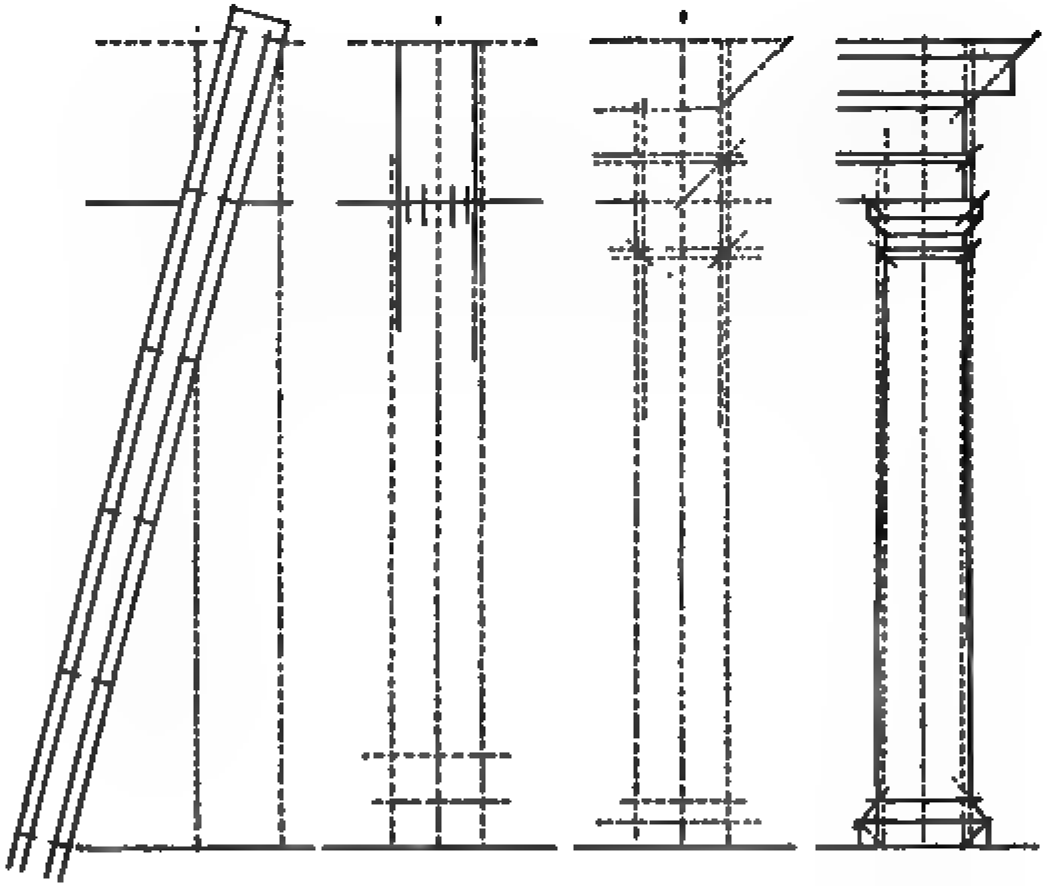
them. He did not adhere closely to his own rules, or generally adopt his orders in his own work. His Doric and Ionic are to be found, however, in the Villa Caprarola.

TUSCAN ORDER—PLATES II AND III

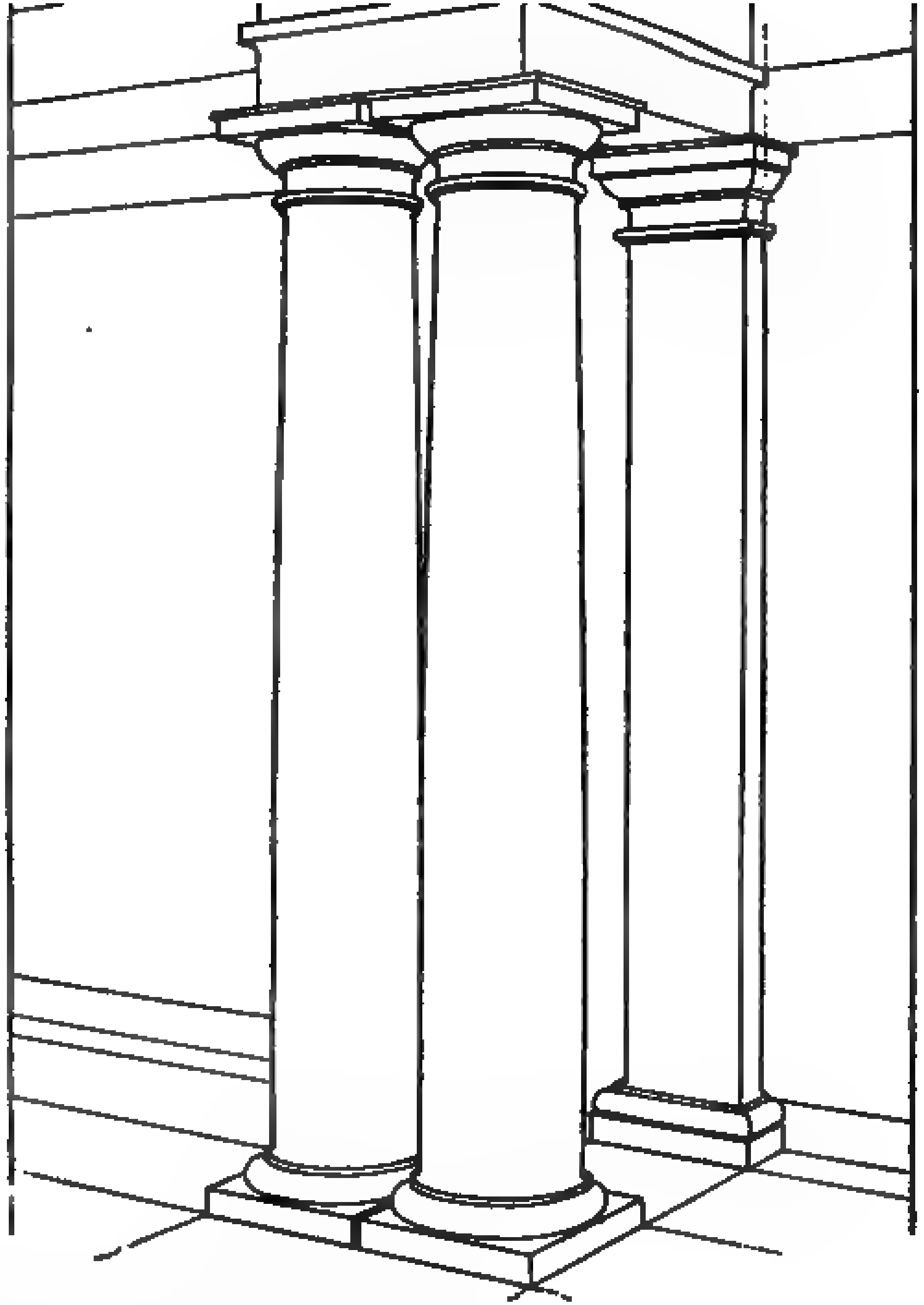
52. The distinguishing characteristic of the **Tuscan order** is simplicity. Any forms of pedestal, column, and entablature that show only few moldings, and those plain, are considered to be Tuscan. Vignola's Tuscan order, Fig. 24, is marked by the use of the ovolo in the cymatium, and by the frequent employment of the congé. The height of the column is seven diameters and that of the entablature, accordingly, seven-quarters, or a diameter and three-quarters. The base, capital, architrave, and frieze are each half a diameter high, and the cornice three-quarters. But this measurement includes not only the base itself, but the cincture at the foot of the shaft. Dividing the cornice into four parts, the capital into three, and the base into two, gives the principal horizontal divisions. The bed mold is a large cyma reversa. The abacus is seven-sixths of a diameter across, not including the fillet at the top, and it projects its own height from the face of the architrave above, which is in line with the necking below.

All the principal dimensions can be expressed in terms of fourths and sixths of the lower diameter of the shaft.

Vignola makes the width of the plinth a little greater than this, and sets the bed mold up one-twelfth, making the frieze wider and the corona narrower.



PLAN OF CAPITAL LOOKING UP



ELEVATION OF CAPITAL AND BASE

PLAN OF BASE

160 152

PLATE II

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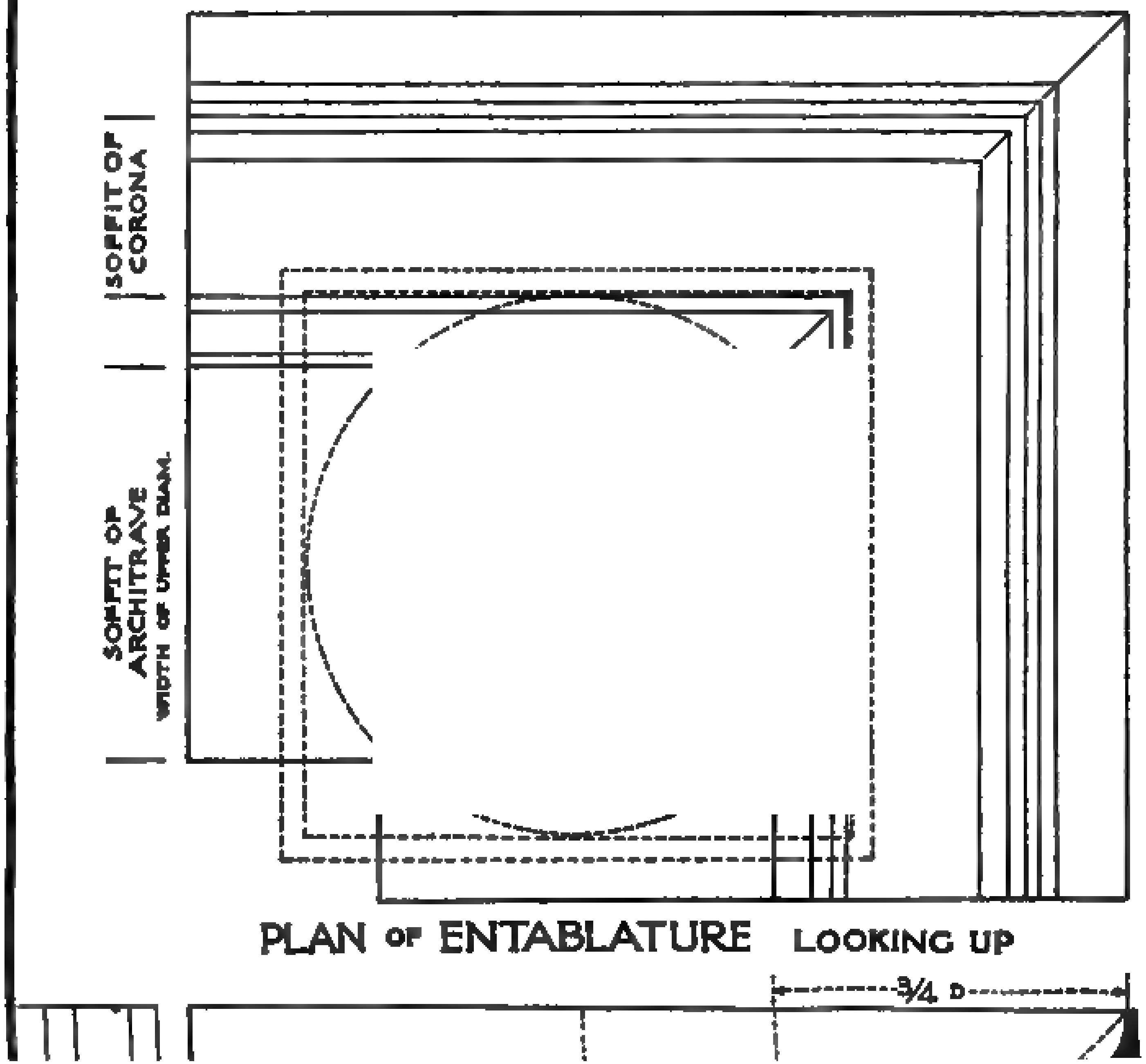
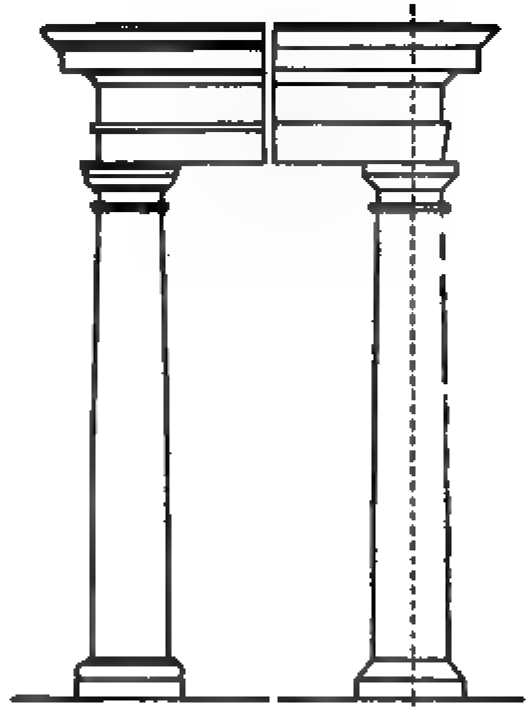
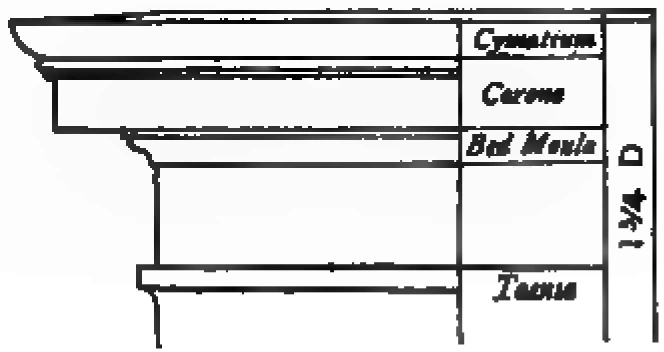


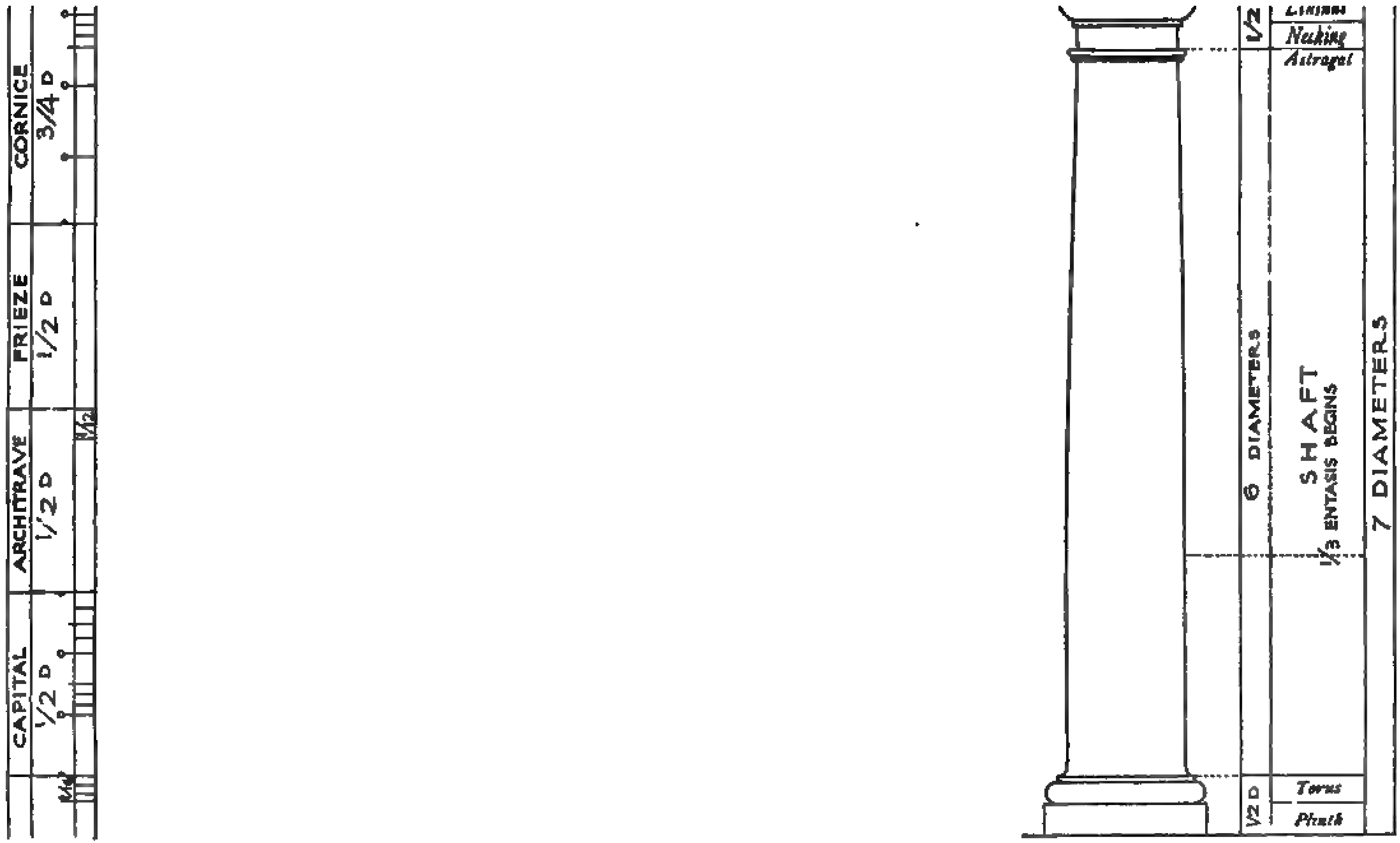
PLAN OF ENTABLATURE LOOKING UP



BLOCK ORDER

COMPLETE ORDER





ELEVATION OF ENTABLATURE

PLATE III

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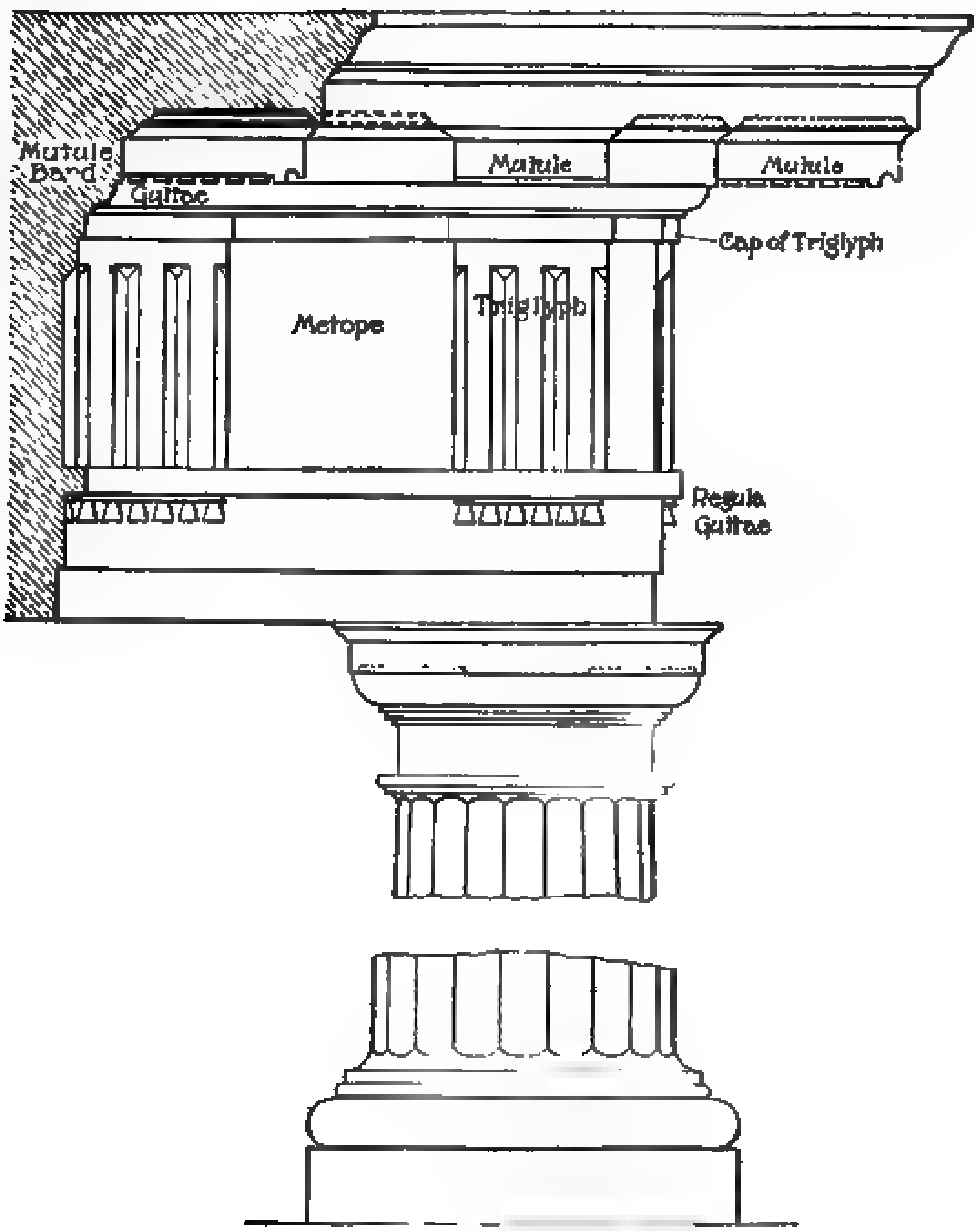
(a)



Mutule Band
Guttae
Mutule
Mutule
Cap of Triglyph
Metope
Triglyph
Regula
Guttae

(b)

Fig. 25

TABLE OF THE TUSCAN ORDER

$\frac{1}{4} D$ equals height of plinth.

$\frac{3}{4} D \text{ equals} \begin{cases} \text{height of cornice.} \\ \text{projection of cornice.} \end{cases}$

$\frac{1}{6} D \text{ equals} \begin{cases} \text{height of necking.} \\ \text{height of echinus.} \\ \text{height of abacus.} \end{cases}$

$\frac{1}{2} D = \frac{3}{6} D \text{ equals} \begin{cases} \text{height of base, including cincture.} \\ \text{height of capital.} \\ \text{height of architrave.} \\ \text{height of frieze.} \end{cases}$

$\frac{5}{6} D$ equals upper diameter of shaft.

$\frac{6}{6} D$ equals lower diameter of shaft.

$\frac{7}{6} D$ equals width of abacus.

$\frac{8}{6} D$ equals width of plinth.

$\frac{1}{12} D$ equals width of tænia.

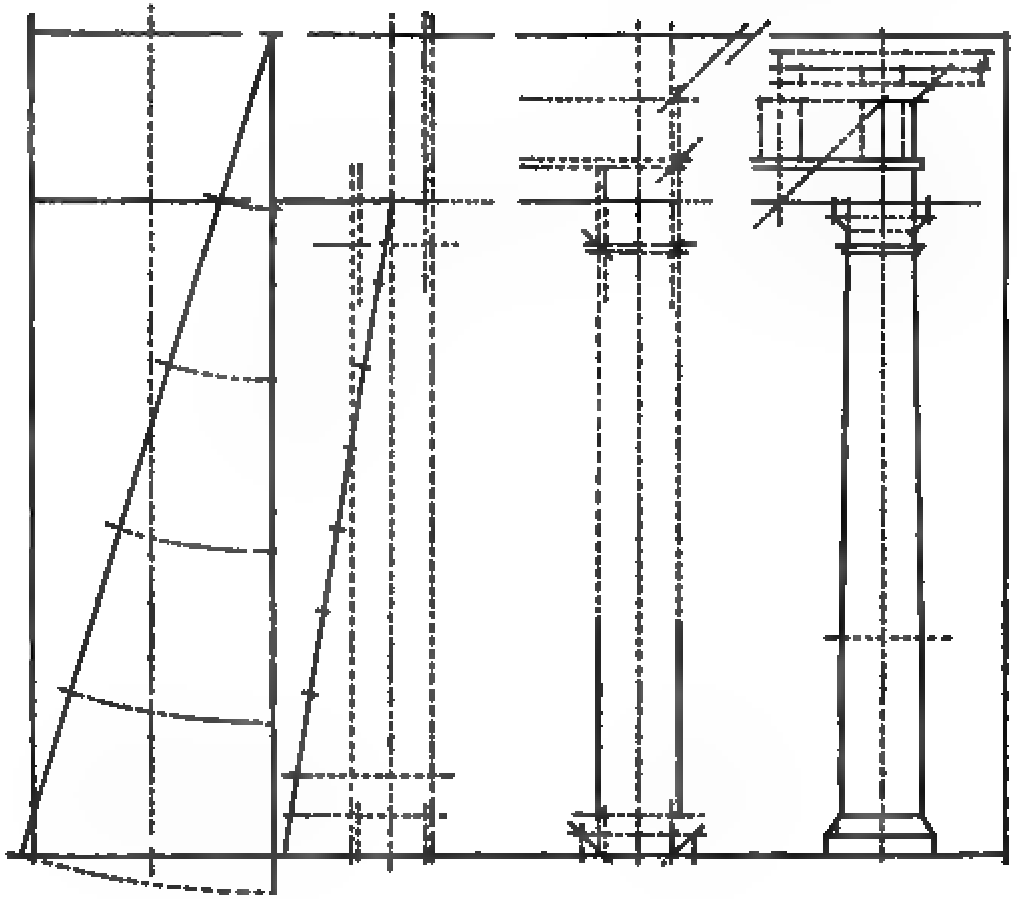
$\frac{1}{16} D \text{ equals} \begin{cases} \text{height of astragal.} \\ \text{projection of astragal.} \end{cases}$

DORIC ORDER—PLATES IV, V, AND VI

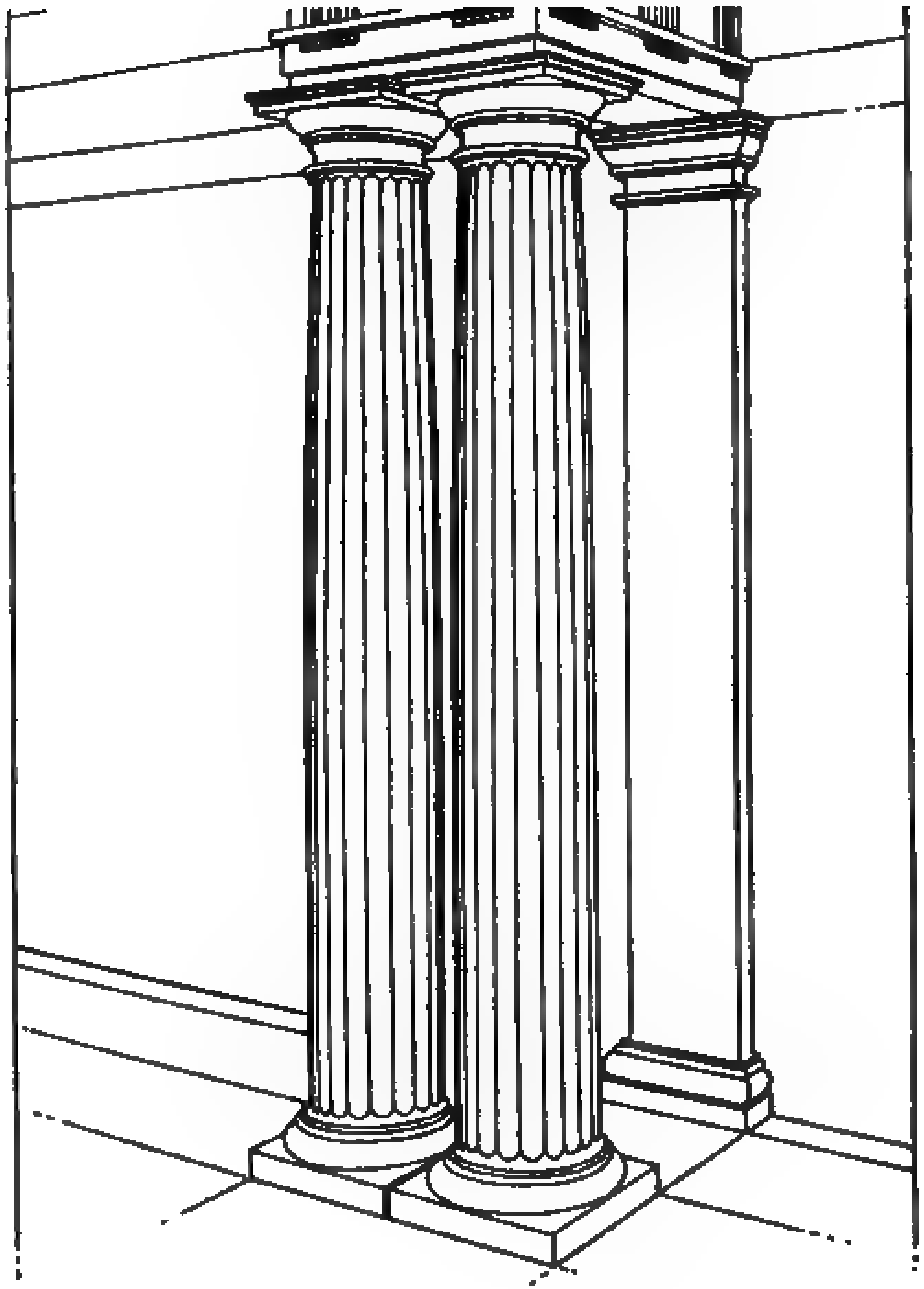
53. The distinguishing characteristics of the **Doric order,** Fig. 25, are features in the frieze and in the bed mold above it, called *triglyphs* and *mutules*, which are supposed to be derived from the ends of beams and rafters in a primitive wooden construction with large beams. Under each triglyph, and beneath the tænia that crowns the architrave, is a little fillet called the *regula*. Under the regula are six long drops, called *guttæ*, which are sometimes conical and sometimes pyramidal. There are also either eighteen or thirty-six short cylindrical guttæ under the soffit of each mutule. The guttæ are supposed to represent the heads of wooden pins, or treenails.

Two styles of the Doric orders are found in the classic monuments, the *mutular*, Fig. 25 and Plate V, and the *den-*

DORIC ORDER



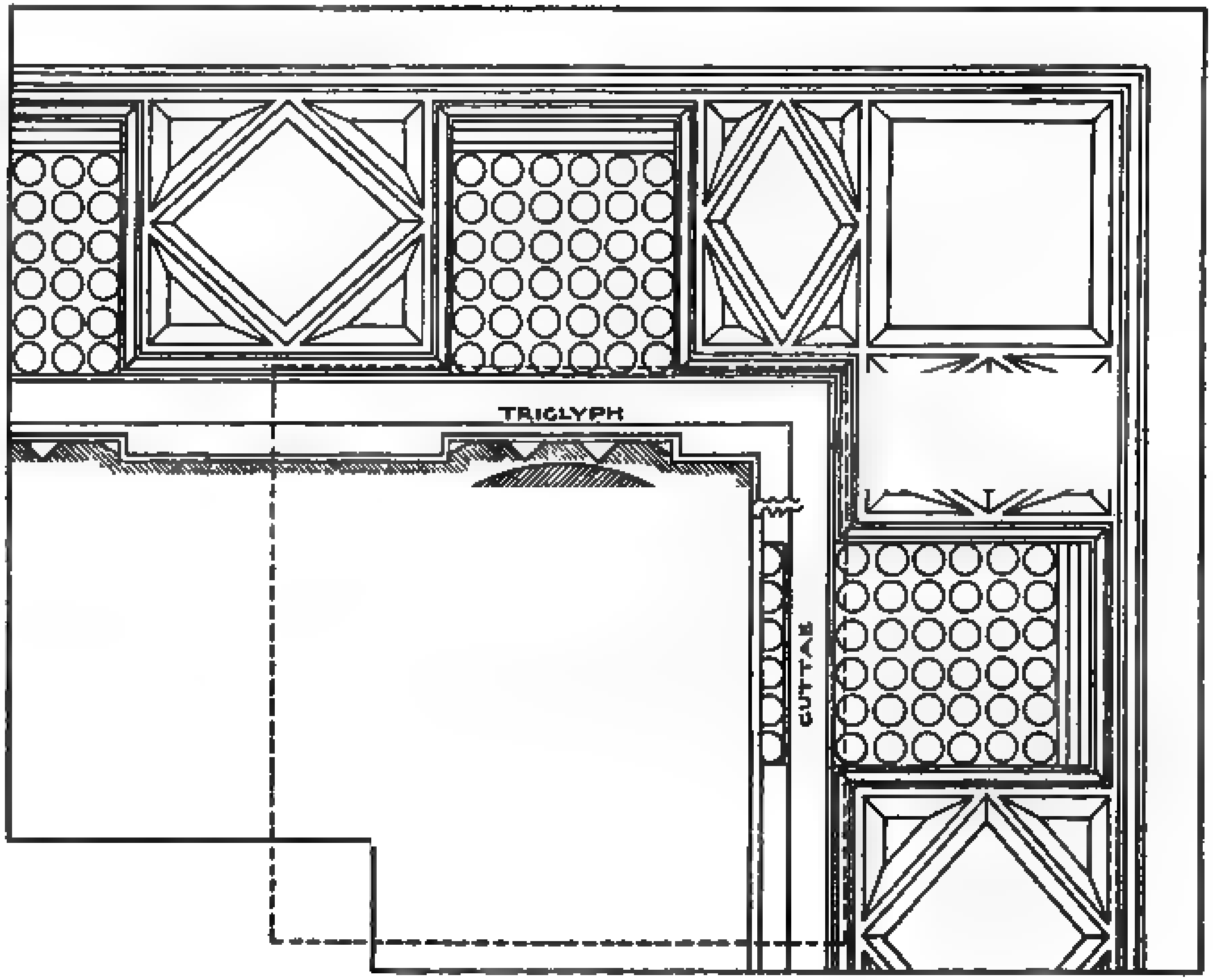
PLAN OF CAPITAL



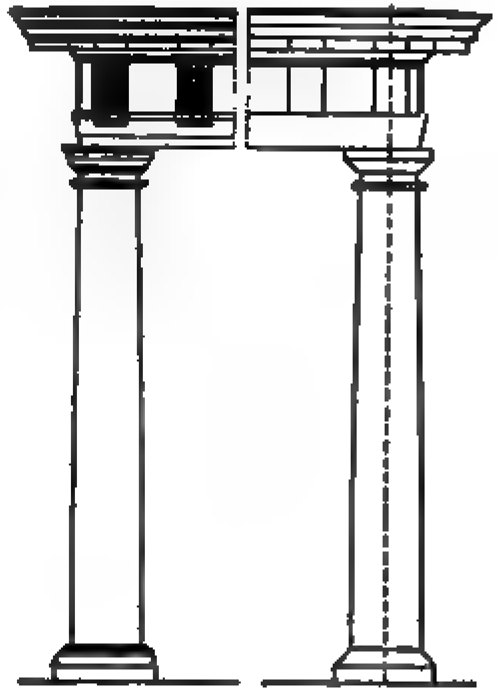
ELEVATION OF CAPITAL AND BASE

PLAN OF BASE

DORIC ORDER

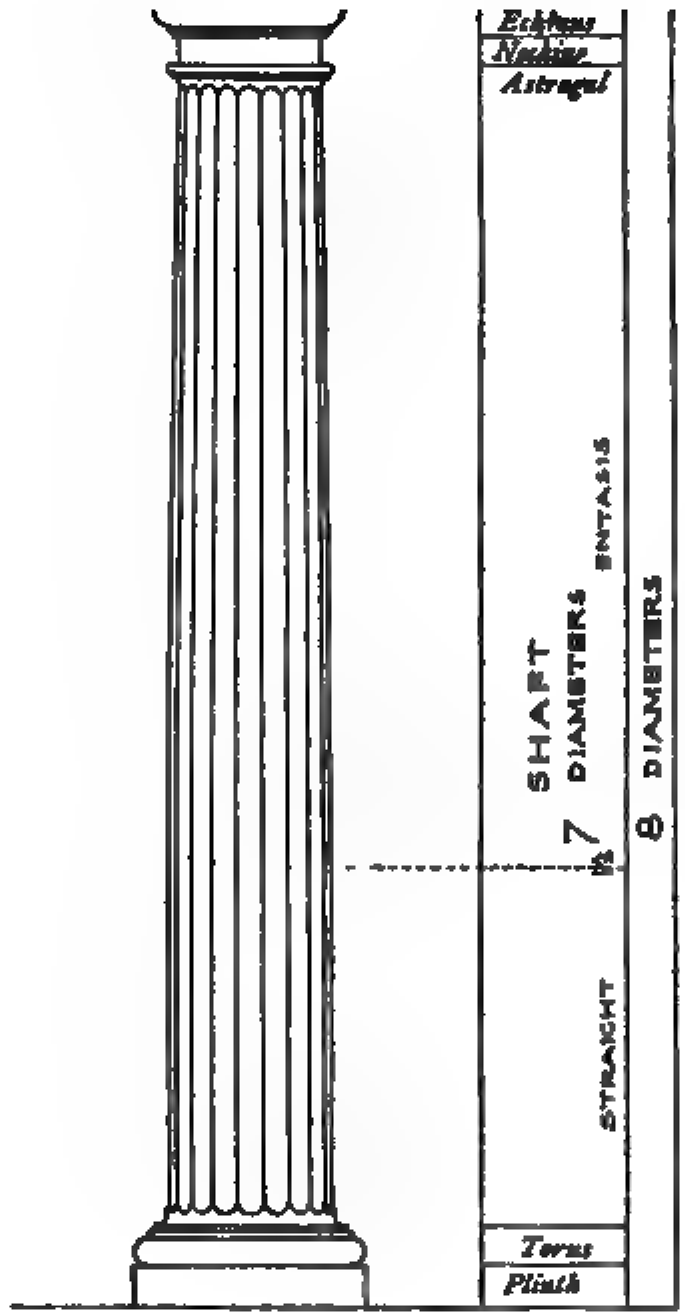


PLAN OF ENTABLATURE LOOKING UP

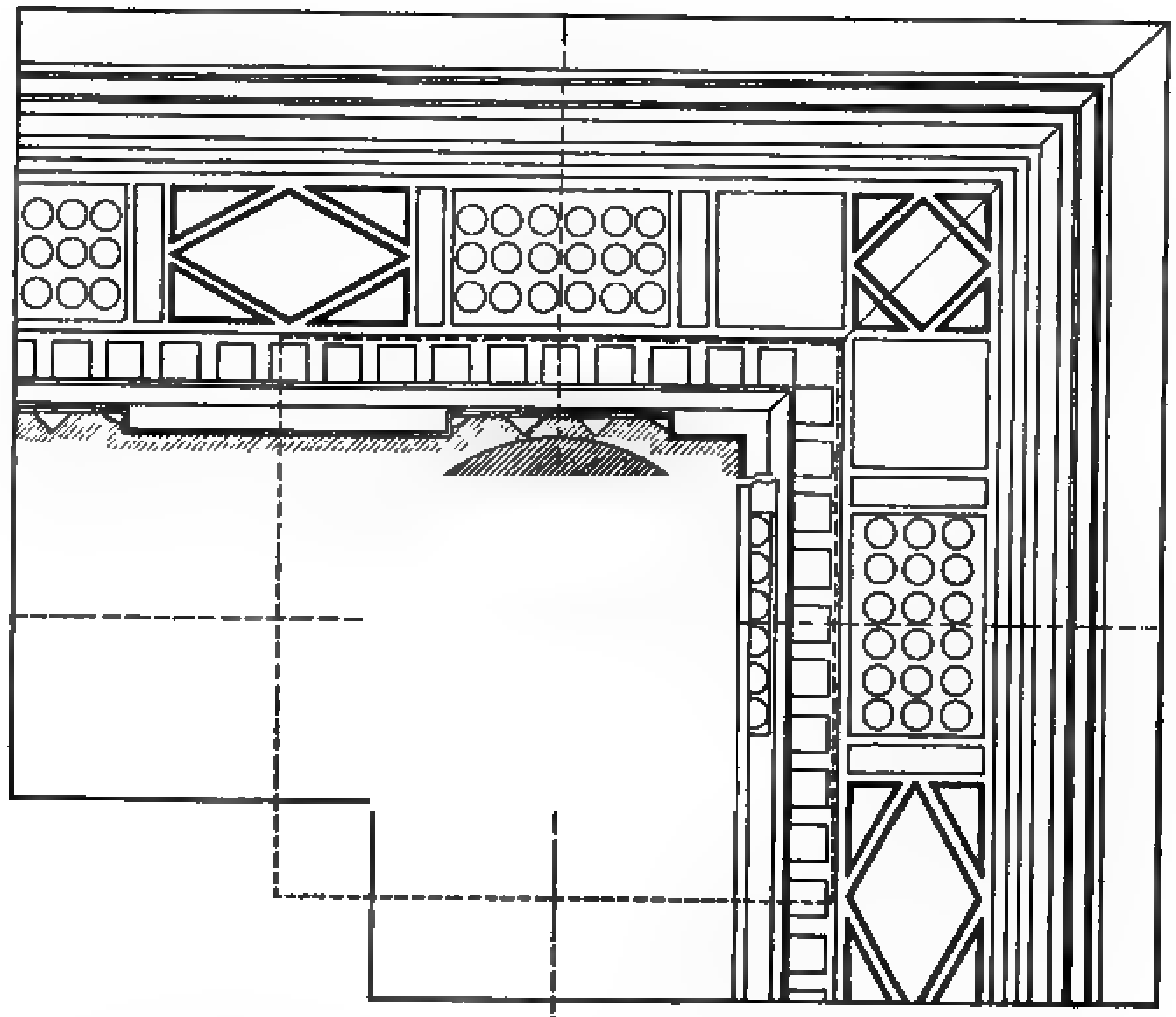


BLOCK ORDER

COMPLETE ORDER

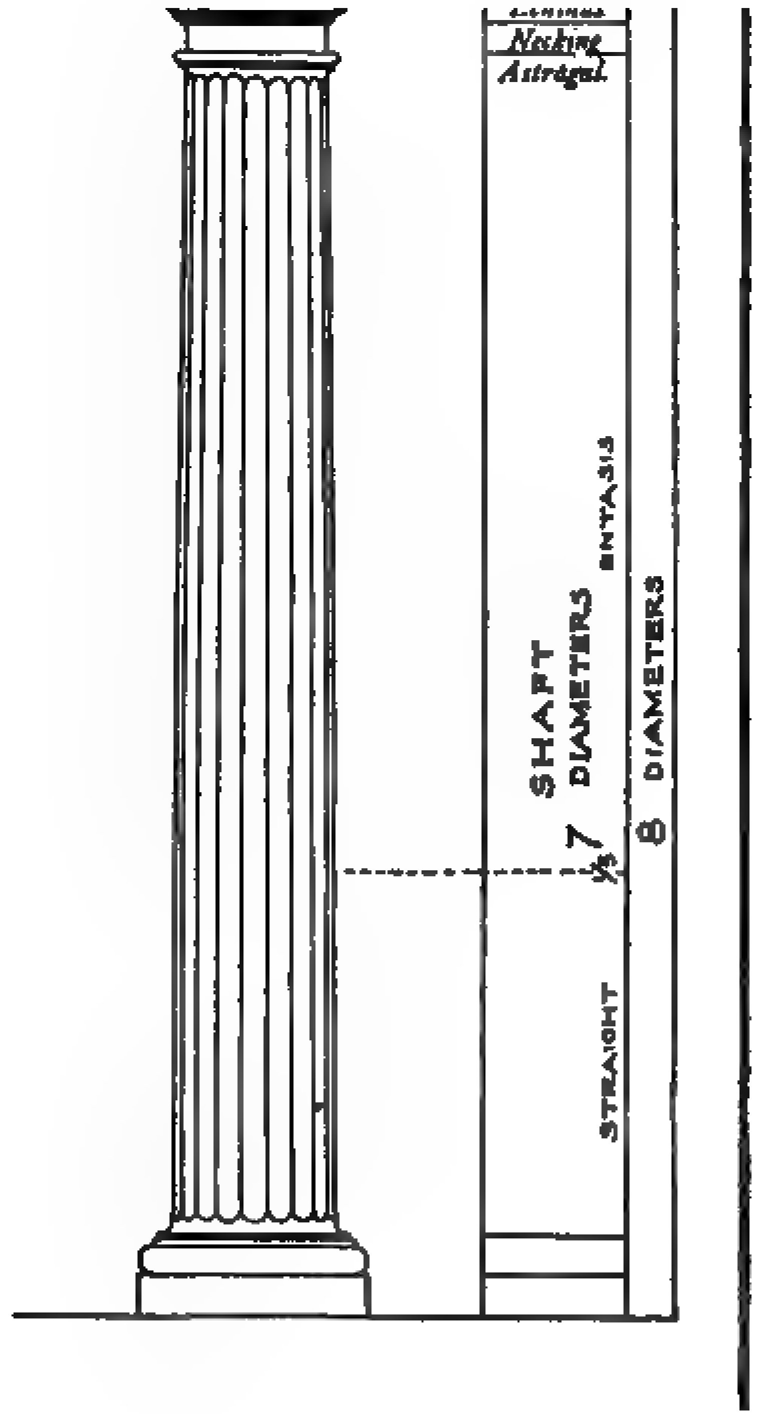


ELEVATION OF ENTABLATURE

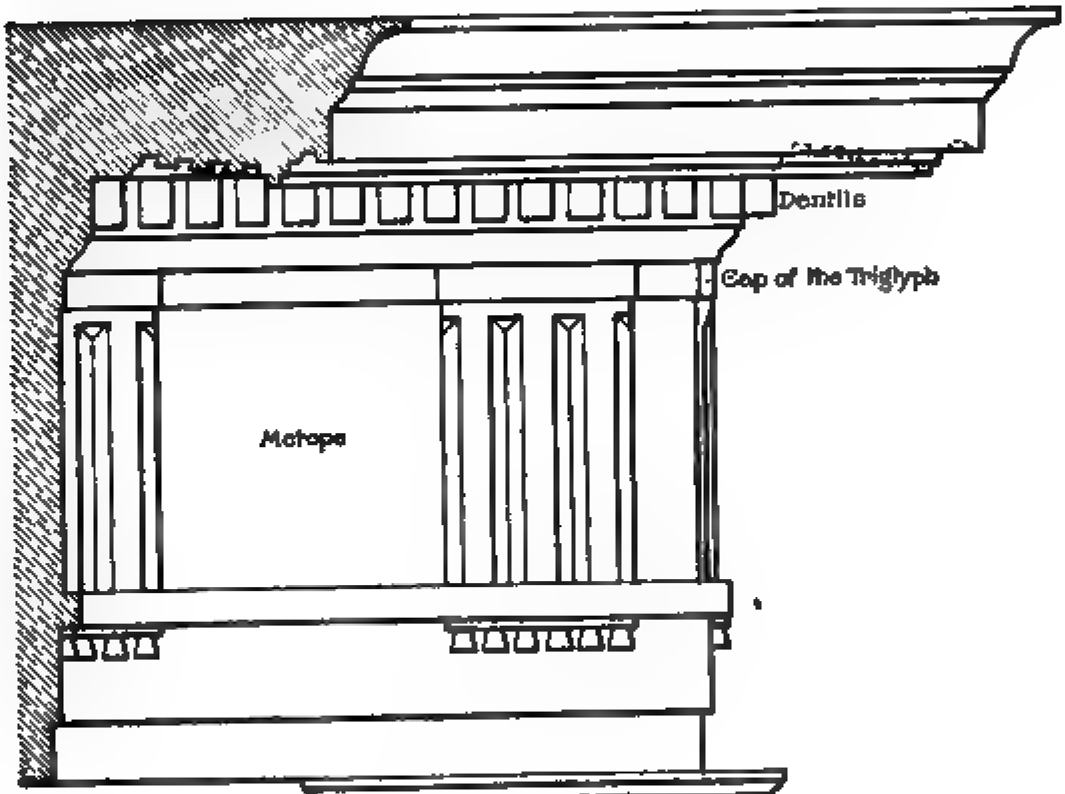


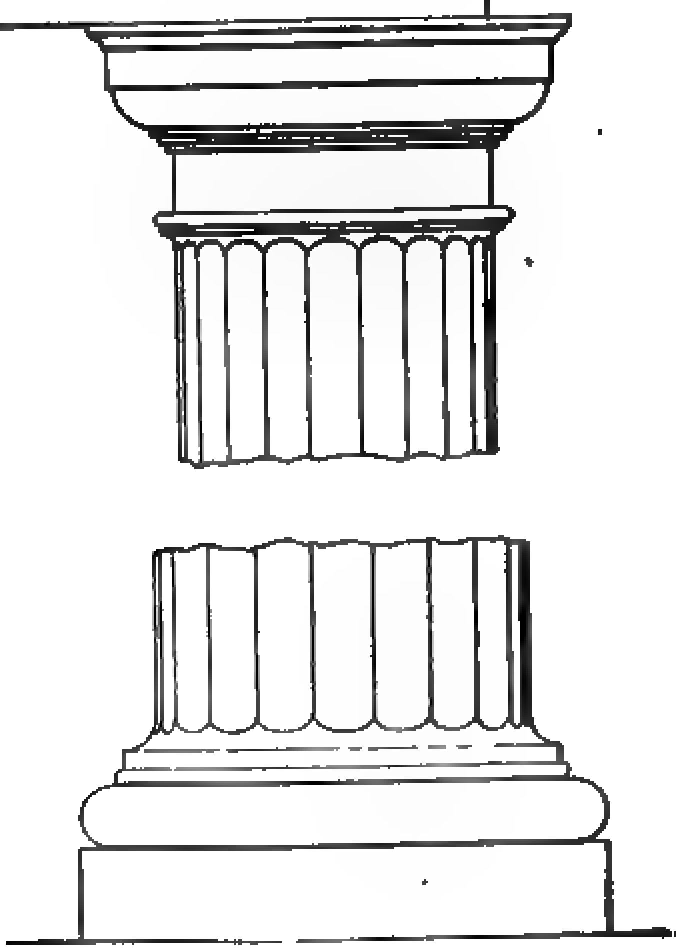
PLAN OF ENTABLATURE LOOKING UP

ELEVATION OF ENTABLATURE



(a)





(b)

Fig. 28

ticulated, Fig. 26 and Plate VI. They differ chiefly in the cornices. In both of them the height—three-quarters of a diameter—is divided into four equal parts, the upper one embracing the gutter, or cymatium, and the fillet below, the next the corona and the small cyma reversa. or cymatium, above it. But the bed molds are unlike. In both of them, the lower member of the bed mold is a broad fillet, a sort of upper tænia, called the *cap of the triglyph*. This, unlike the tænia below, breaks around the angles of the triglyph, serving as a sort of crowning member, or cymatium, to both the triglyph and the metope.

54. Mutular Doric.—In the **mutular Doric**, Fig. 25, above the cap of the triglyph, is a narrow fillet that does not break around the angles and accordingly shows a broad soffit over the metopes and at the corner of the building. These two fillets occupy the lower half of the lower quarter of the cornice. The upper half of the lower quarter, above this little fillet, is an ovolo, and above this, the second quarter of the cornice is occupied by a broad fascia, called the *mutule band*, on which are planted the mutules, one over each triglyph, which are half a diameter wide, like the triglyphs below them. They are broad, low, oblong brackets, crowned with a fillet and cyma reversa, which also crown the mutule band between the brackets. On the soffit of each mutule are thirty-six guttæ and a drip molding.

55. Denticulated Doric.—In the **denticulated Doric**, Fig. 26, the place of the fillet and ovolo above the cap of the triglyph is taken by a large cyma reversa, the soffit of which is wider over the metopes than over the triglyphs, as is that of the small fillet in the mutulary. Above this molding is a band like the mutule band, but instead of brackets, extending out under the corona, it bears a row of small blocks, like teeth, called *dentils*. These are one-eighth of a diameter high, and are set one-eighth of a diameter from center to center, or edge to edge. If this last dimension is divided into thirds, two of these go to the

dentil, and one to the space between it and the next one. This space is called an *interdentil*, which is accordingly one twenty-fourth of a diameter wide. The dentil is thus one-eighth of a diameter long and one-twelfth wide, or half a sixth, or of the proportions of two to three, like the triglyph. The face of the last dentil on the corner and the side of the first one around the corner come together in elevation without any interdentil, giving the appearance of a *double dentil*, for the dentils are square in plan and the side is just as wide as the face.

As the triglyphs are a diameter and a quarter on centers, or ten-eighths, there are ten dentils to each triglyph and metope.

A dentil comes just over the axis of each column and there are three dentils between the one over the corner column and the double dentil on the corner, the farther edge of the third one being just over the face of the frieze, or five-twelfths of a diameter from the axis of the column.

The last dentil, or first half of the double dentil, is centered over the outer face of the bottom of the shaft (see Fig. 42).

The dentils constitute the upper member of the bed mold. They leave the chief part of the corona unsupported, but the soffit of the corona, which is slightly inclined, recalling the slope of the rafters, is not so wide as the soffit of the mutulary Doric, owing to this encroachment of the dentils. The mutules, which are very shallow, have, accordingly, only eighteen guttæ in place of thirty-six; that is, three rows, instead of six. There is also a mutule over each metope, as well as one over each triglyph.

56. Vignola gives his denticulated Doric a large cavetto for a cymatium, or gutter, instead of a cyma recta, and supports the echinus of the capital by three fillets, instead of by a fillet and bead, Fig. 26 (*b*).

The triglyphs are three-quarters of a diameter high and half a diameter wide, as shown in Fig. 27. This width is

divided into three parts, called *shanks* or *femurs*. Each shank is beveled on the edge nearly up to the top of the triglyph, making in all two channels and two half channels. Each shank is one-sixth of a diameter wide and each beveled face a quarter of a sixth. The plain face of the shank is, accordingly, one-twelfth, and just as wide as the channel. These are almost the only beveled faces to be found in the whole range of classical architecture, though beveled fillets are not uncommon. The two full channels are generally cut in at an angle of 45°, but the two half channels on either side are shallower, and do not reach the face of the frieze.

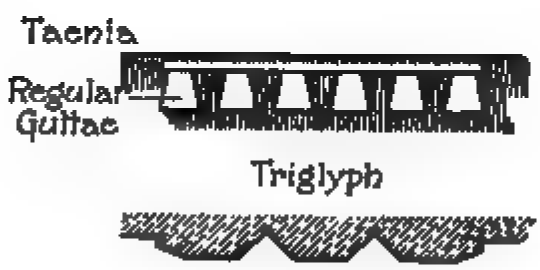


Fig 27

The triglyphs come just over the columns. The portion of the frieze between the triglyphs is called a *metope*. It is exactly square, being three-quarters of a diameter wide. The fragment of a metope between the last triglyph and the corner of the frieze is one-sixth of a diameter wide. The face of the metopes comes over the lower band of the architrave, and that of the triglyph projects slightly beyond the face of the upper band.

The column is eight diameters in height, the base, capital, and architrave each half a diameter, and the frieze and cornice each three-quarters. The total projection of the cornice, including the cymatium, is one diameter. The architrave is divided into two bands, or fasciæ. The lower one occupies the lower third of the architrave, and the tænia, regula, and guttæ the upper third. Half of this third goes to the tænia, the projection of which equals its height.

57. The Doric column has twenty *channels*, each about one-sixth of a diameter wide, which show in section, Fig. 28, an arc of 60°. The solid edge that separates them, called the *arris*, makes an angle of something over 90° (102°). The ten arrises shown in elevation are easy to draw, as two come on the outline of the shaft, two come on its "corners," and the two middle ones are almost exactly one-sixth of a diameter apart. The channels are .157 of a diameter wide, so that making the middle one one-sixth, or .166, of a diameter involves an error of only .009 of a diameter, or about one-eighteenth of its width. The four other arrises can then be put in without much difficulty.

FIG. 28

58. The Doric base and capital, Figs. 25 and 26, are divided, like the Tuscan, into halves and thirds, but with additional moldings, a bead being added above the torus of the base and another below the echinus of the capital. The abacus is crowned by a cymatium consisting of a fillet and cyma reversa. If the height of the capital is divided into thirds, the two upper thirds again into thirds, and the upper and lower of these still again into three equal parts, all the horizontal lines of the capital will be determined, as shown in Plate VI.

Vignola's denticulated Doric is imitated closely from the Doric order of the Theater of Marcellus, and the mutulary Doric, which he has been credited with inventing, seems to have been derived from the Doric order of the Basilica Julia. There are no Roman Doric temples.

TABLE OF THE DORIC ORDER

$\frac{3}{4}D$ equals $\left\{\begin{array}{l}\text{height of frieze.}\\ \text{height of corniee.}\\ \text{projection of corona (denticulated).}\\ \text{projection of mutule (mutulary).}\\ \text{width of metope.}\end{array}\right.$

$\frac{1}{4}D$ equals height of plinth.

$\frac{1}{6}D$ equals $\left\{\begin{array}{l}\text{projection of plinth.}\\ \text{projection of abacus.}\\ \text{height of abacus.}\\ \text{height of necking.}\\ \text{height of echinus and bead.}\\ \text{height of lower band.}\\ \text{height of guttæ, regula, and tænia.}\\ \text{width of shank.}\\ \text{width of corner metope.}\end{array}\right.$

$\frac{1}{2}D = \frac{3}{6}D$ equals $\left\{\begin{array}{l}\text{height of base, including the cincture.}\\ \text{height of capital.}\\ \text{height of architrave.}\\ \text{width of triglyph.}\end{array}\right.$

$\frac{1}{8}D$ equals height of dentils.

$\frac{1}{12}D$ equals $\left\{\begin{array}{l}\text{width of dentils.}\\ \text{height of tænia.}\\ \text{projection of tænia.}\end{array}\right.$

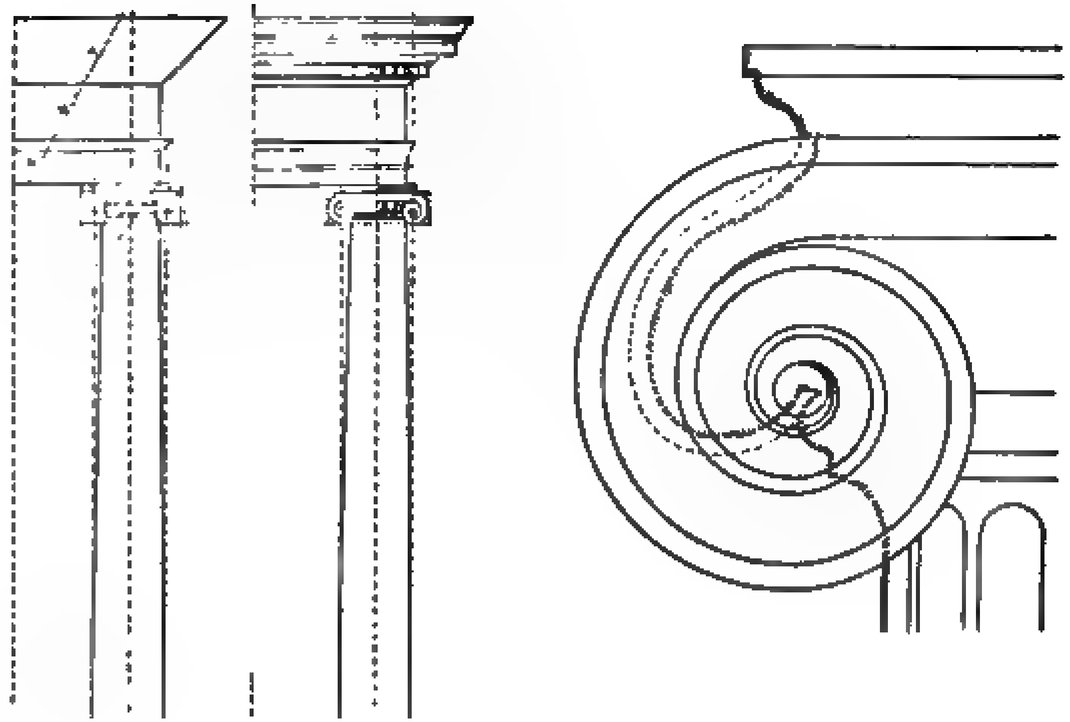
$\frac{1}{16}D$ equals $\left\{\begin{array}{l}\text{height of astragal.}\\ \text{projection of astragal.}\end{array}\right.$

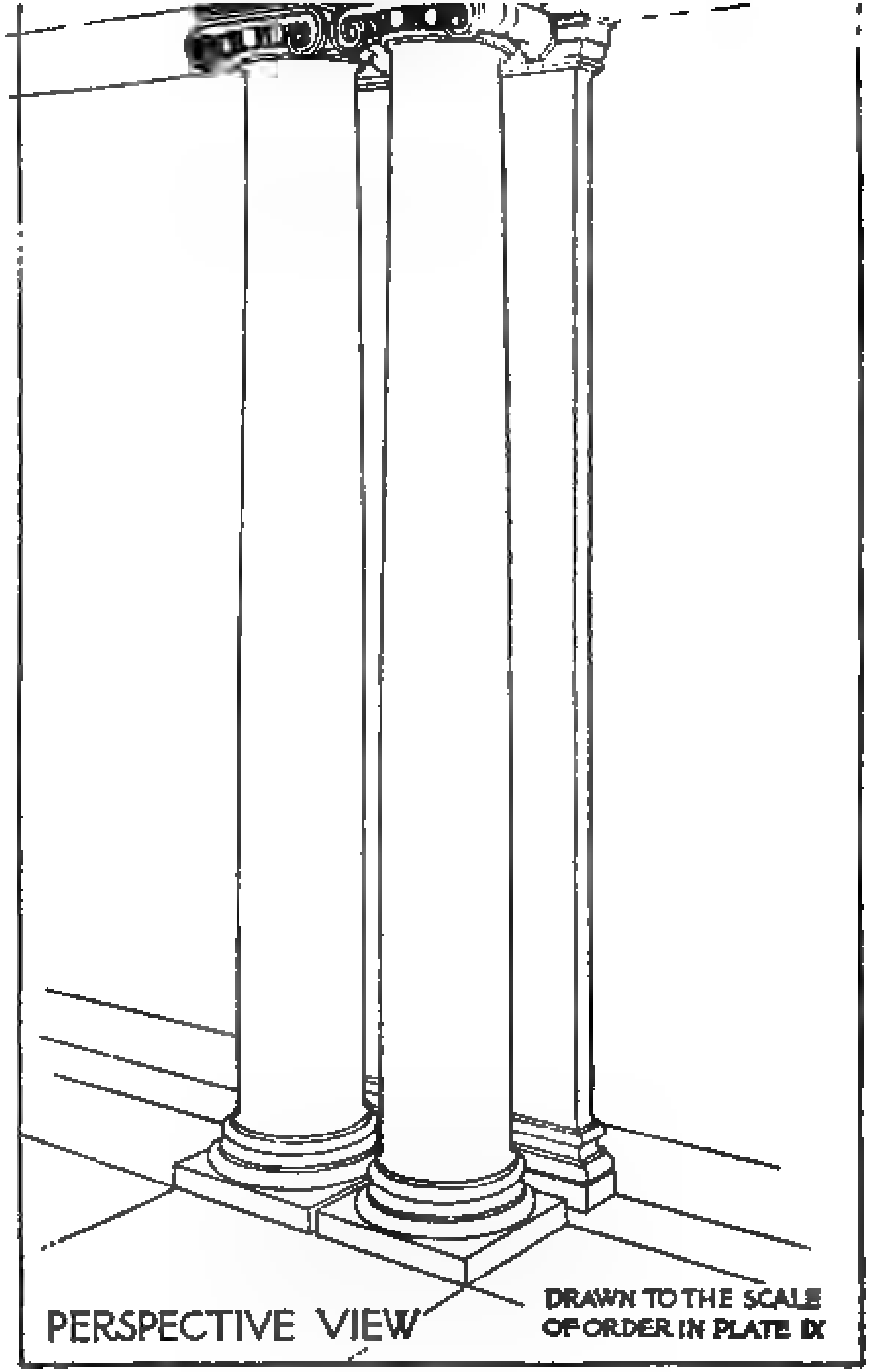
$\frac{1}{24}D$ equals width of interdentils.

IONIC ORDER—PLATES VII AND VIII

59. The prototypes of the **Ionic order** are to be found in Persia, Assyria, and Asia Minor (see Fig. 33, *History of Architecture and Ornament*, Part 1). Like the Doric order, it seems to have originated in a wooden construction. It is characterized by bands in the architrave and dentils in the

PLAN OF CAPITAL





PERSPECTIVE VIEW

VIGNOLA'S
BASE

ELEVATION OF CAPITAL BASE

PLAN OF BASE

PLATE VII

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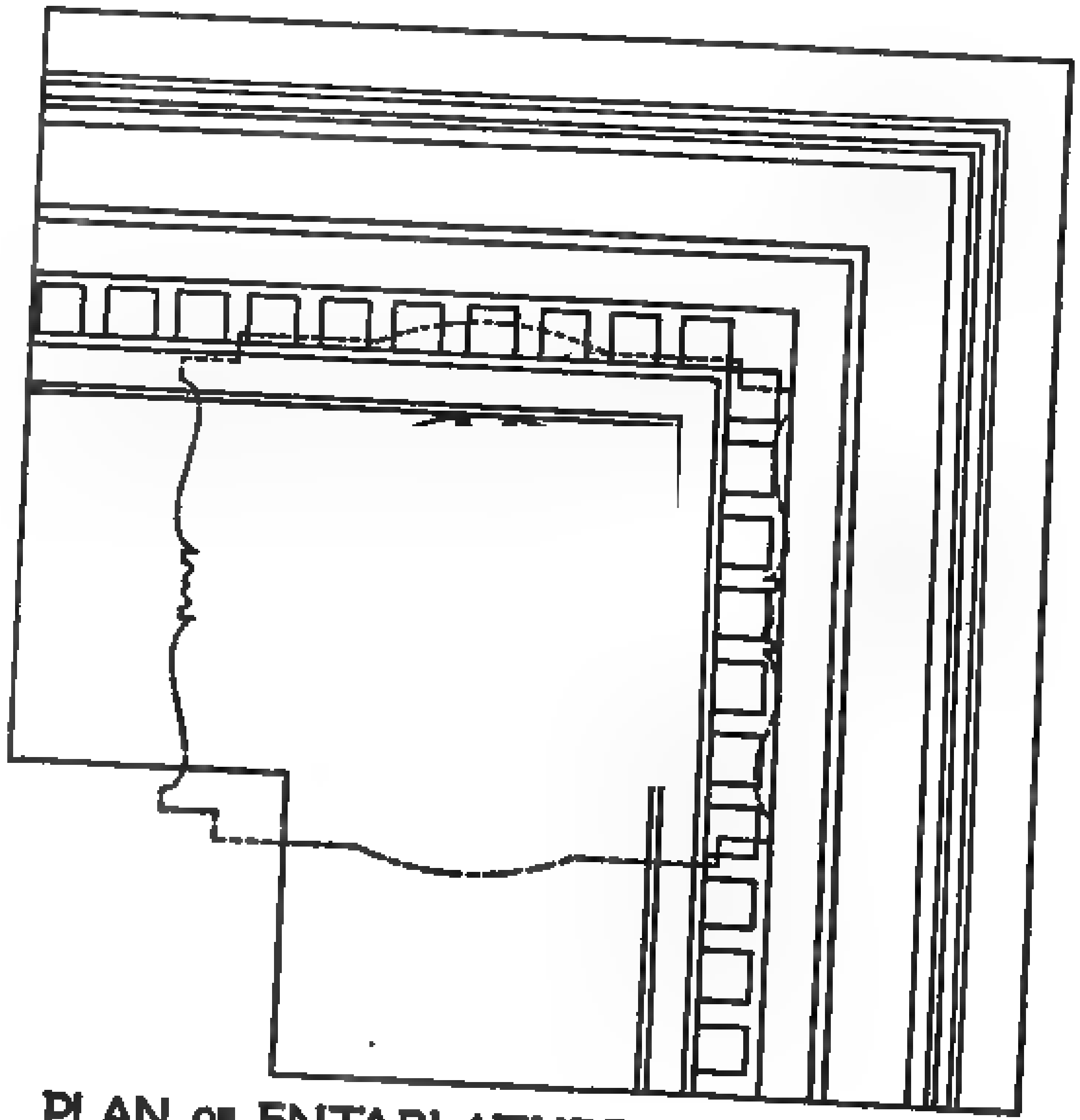
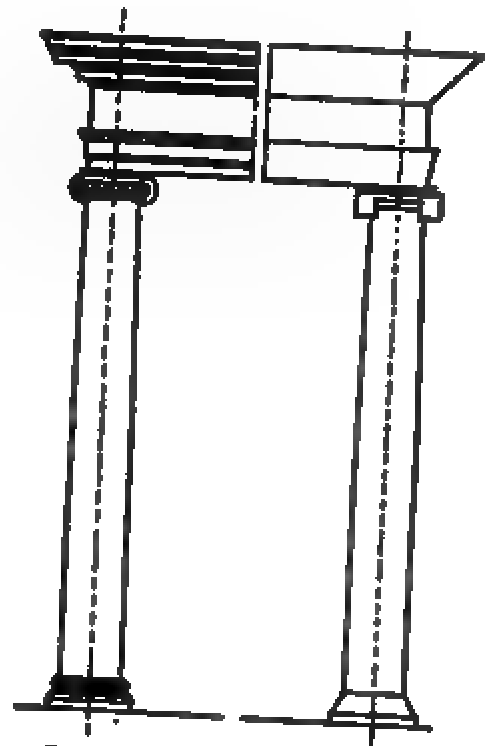
IONIC ORDER

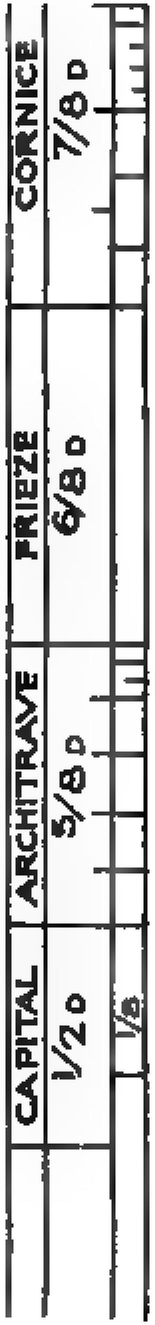


PLAN OF ENTABLATURE LOOKING UP



BLOCK ORDER

COMPLETE ORDER



ELEVATION OF ENTABLATURE

PLATE VIII

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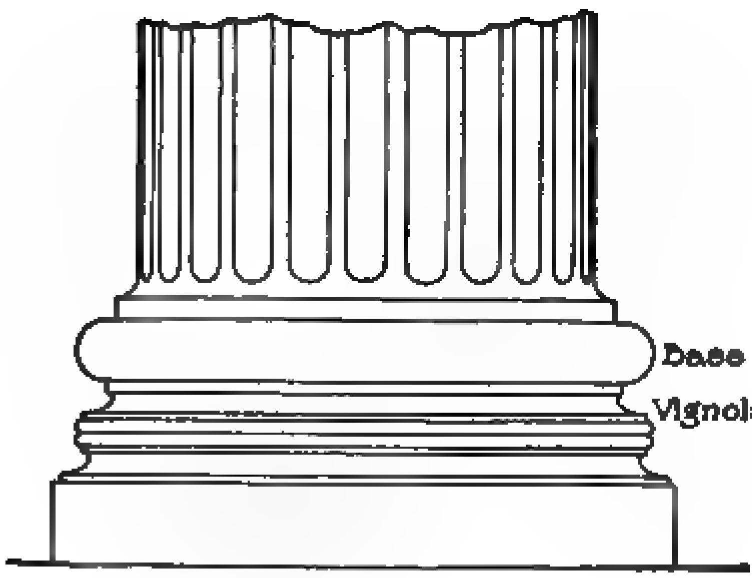


Fig. 29

bed mold, both of which are held to represent sticks laid together to form a beam or a roof. But the most conspicuous and distinctive feature is the *scrolls* that decorate the capital of the column. These have no structural significance, and are purely decorative forms derived from Assyria and Egypt. Originally, the Ionic order had no frieze and no echinus in the capital. These were borrowed from the Doric order, and, in a similar manner, the dentils and bands in the Doric were imitated from the Ionic. The Ionic frieze was introduced in order to afford a place for sculpture, and was called by the Greeks the *Zoöphorus*, or figure bearer, Fig. 29.

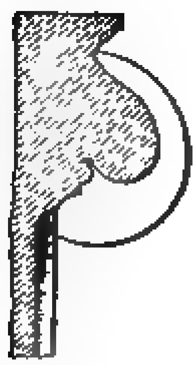
60. In the Ionic entablature, the architrave, frieze, and cornice are of about the same height, each measuring about three-quarters of a diameter. But Vignola makes the architrave a little smaller and the cornice a little larger, so that they measure, respectively, five-eighths, six-eighths, and seven-eighths of a diameter. The architrave is divided into five parts, each an eighth of a diameter in height. The upper one is occupied by a large cyma reversa and a fillet, which take the place of the Doric tænia. Below are two fasciæ, or bands, of equal height, each measuring a quarter of a diameter. The lower one is crowned by an ovolo and fillet. The French often use three bands, as in the Corinthian architrave.

The Ionic frieze is plain, except for the sculpture on it. It sometimes has a curved outline, as if ready to be carved, and is then said to be *pulvinated*, from *pulvinar*, a bolster, which it much resembles.

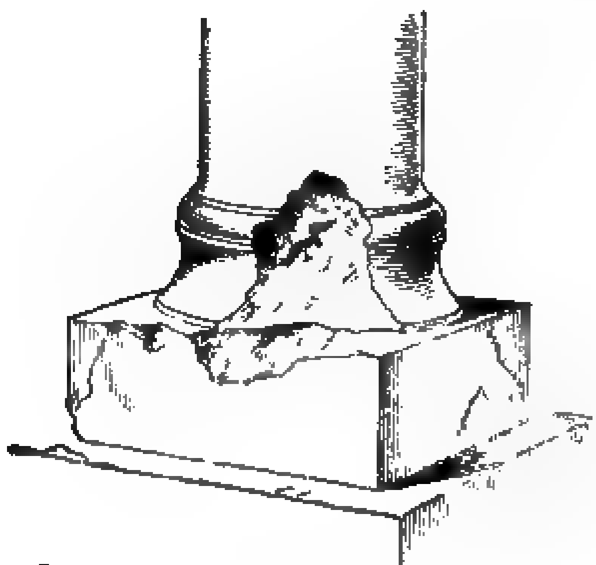
61. The cornice is much like that of the denticulated Doric, which was derived from it, but has no mutules. The upper half, as in the Doric, is taken up by the cymatium and corona, and the lower half by the bed mold. This is divided into four equal parts, of which the upper one is given to an ovolo, the lower to a cyma reversa and fillet, and the two middle ones to a dentil band and fillet. On this band are planted the dentils, which are one-sixth of a diameter high, and are set one-sixth on centers, or on edges, instead of one-

eighth, as in the denticulated Doric. Two-thirds of this sixth go to the width of the dentil and one to the space between, or interdentil. The dentil is, accordingly, one-ninth of a diameter wide, and the interdentil one-eighteenth, instead of a twelfth and a twenty-fourth. A dentil is put on the axis of a column, and an interdentil comes just over the outer line of the frieze. There is, apparently, a double dentil on the corner, the outer face of which is two-thirds of a diameter, or four-sixths, from the axis of the column. The first half of it, as in the denticulated Doric, comes over the outer face of the lower end of the shaft (see Fig. 42). There are two dentils between the one over the column and the double dentil, in place of three, as in the Doric.

62. The Ionic capital, like the Doric, has an echinus and an abacus crowned by a cyma reversa and fillet. But generally it has no necking, and it is, accordingly, only two-sixths of a diameter in height, or one-third instead of one-half. Both the echinus and the cymatium that crown the abacus are larger than in the Doric, and the face of the abacus smaller, and the echinus projects in front of the abacus, instead of being covered by it. The abacus and its fillet extend beyond the echinus on either side, and are curled up into the scrolls, or *volutes*, as shown in Fig. 30 (*a*), the whole height of which is a half diameter, measuring down from the architrave. The *eyes* of the scrolls are one-third of a diameter from the top, on the line separating the bottom of the capital from the top of the astragal that crowns the shaft. They are just one diameter apart on centers, coming over the outer lines of the lower end of the shaft, and the inner edges of the scrolls are two-thirds apart. The echinus is generally carved with eggs and darts, three of which show between the scrolls, the next one on either side being hidden by sprigs of honeysuckle ornament. These scrolls, Fig. 30 (*b*), show on the sides a series of moldings called the *baluster*, or *bolster*, as in (*c*), a section through the center of which is shown in (*d*). The term abacus is generally held to apply only to the cyma reversa and fillet, above the scrolls.



(c) (d) (e)



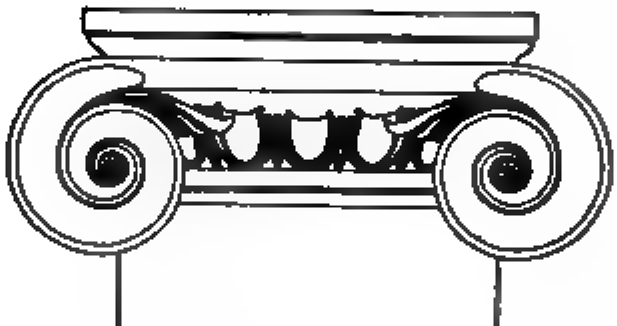
Base of Choragic Column (Athens)

(f)

Attic Base

(g)

FIG. 80



Theater of Marcellus

(a)

Temple of Fortuna Virilis.

(b)

Roman Capital (in the Lateran Museum)

(c)

Scamozzi Capital

(d)

FIG. 31

63. The shaft of the column is ornamented with twenty-four *flutings*, Fig. 30 (*e*), semicircular in section, which are separated not by an arris, but by a fillet of about one-fourth their width. This makes the flutings only about two-thirds as wide as the Doric channels, or about one-ninth of a diameter, instead of one-sixth. Four-fifths of one twenty-fourth of the circumference is .106 of a diameter, while one-ninth of the diameter is .111, a difference of less than a twentieth.

64. The original Greek-Ionic base is considered to have consisted simply of a scotia, and small torus above, as in Fig. 30 (*f*). It is common in modern practice, however, to use instead what is called the *Attic base*, Fig. 30 (*g*), consisting of a scotia and two fillets between two large toruses, mounted on a plinth, the whole being half a diameter high. The plinth occupies the lower third, or one-sixth of a diameter. Vignola adopted for his Ionic order a modification of the Attic base, substituting for the single large scotia two small ones, separated by one or two beads and fillets and omitting the lower torus, as shown in Fig. 29.

65. The principal ancient examples of the Ionic order in Rome are those of the Theater of Marcellus and the Temple of Fortuna Virilis, as shown respectively in Fig. 31 (*a*) and (*b*) and in Figs. 72 and 84, *History of Architecture and Ornament*, Part 1. The Ionic capital sometimes has a necking like the Doric, which is then generally decorated, as in Fig. 31 (*c*). Sometimes, also, the four faces of the capital are made alike, double scrolls occurring at the corners, where they project at an angle of 45°. In this case there is no baluster, and the capital resembles the upper portion of a Composite capital. It is then sometimes called the Roman Ionic capital, or the Scamozzi capital, Fig. 31 (*d*), from the name of the architect Scamozzi, who frequently employed it.

Almost all the dimensions of the Ionic order can be expressed in terms of sixths of a diameter, as appears in the following table:

TABLE OF THE IONIC ORDER

$\frac{5}{8}$ D equals height of architrave.

$\frac{3}{4}$ D = $\frac{6}{8}$ D equals height of frieze.

$\frac{7}{8}$ D equals { height of cornice. / projection of cornice.

$\frac{1}{4}$ D = $\frac{2}{8}$ D equals height of each band.

$\frac{1}{8}$ D equals { projection of plinth. / height of plinth. / height of dentils. / distance of dentils, o. c. / projection of abacus.

$\frac{1}{3}$ D = $\frac{2}{6}$ D equals height of capital.

$\frac{1}{2}$ D = $\frac{3}{6}$ D equals { height of base. / height of scrolls.

$\frac{2}{3}$ D = $\frac{4}{6}$ D equals { distance between scrolls. / distance from axis to outer face of double dentil.

$\frac{5}{6}$ D equals upper diameter.

1 D = $\frac{6}{6}$ D equals { lower diameter. / distance of eyes of scrolls, o. c. / length of baluster.

$\frac{7}{6}$ D equals width of abacus.

$1\frac{1}{3}$ D = $\frac{8}{6}$ D equals { width of plinth. / width of echinus (minus).

$1\frac{1}{2}$ D = $\frac{9}{6}$ D equals width of scrolls (minus).

$\frac{1}{6}$ D equals { width of dentil. / width of fluting.

$\frac{1}{12}$ D equals { height of astragal. / projection of astragal.

$\frac{1}{18}$ D equals width of interdentil.

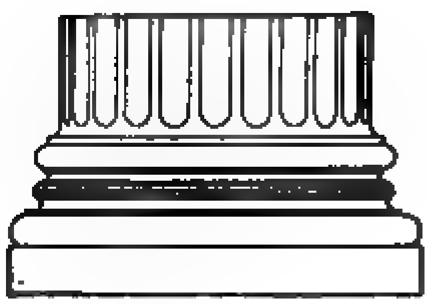
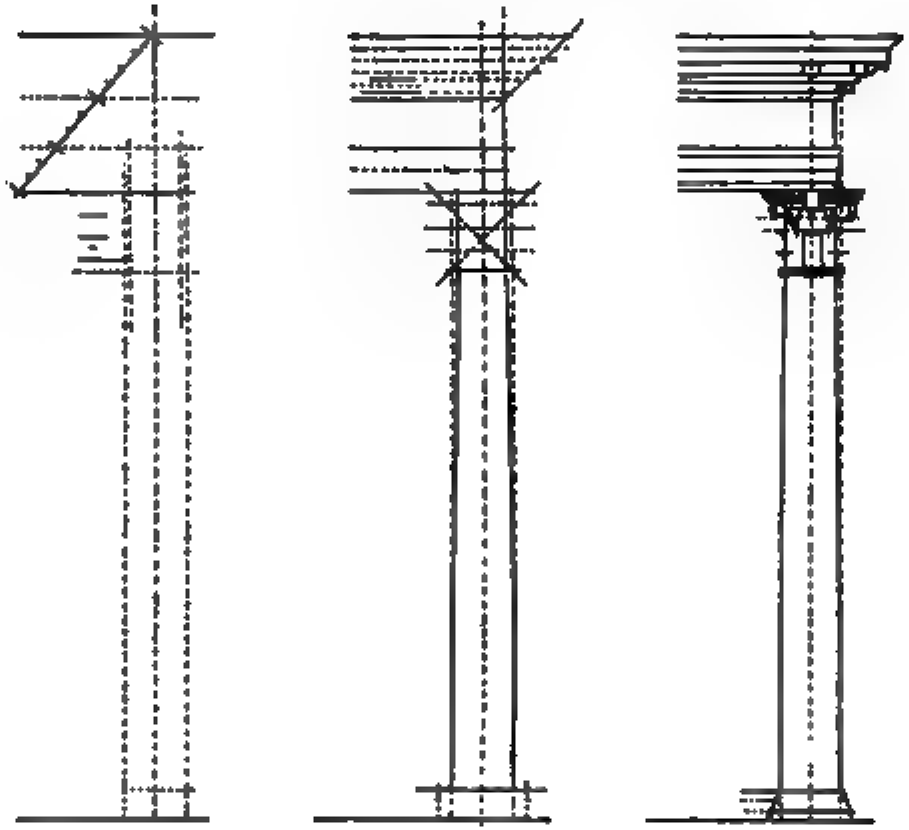
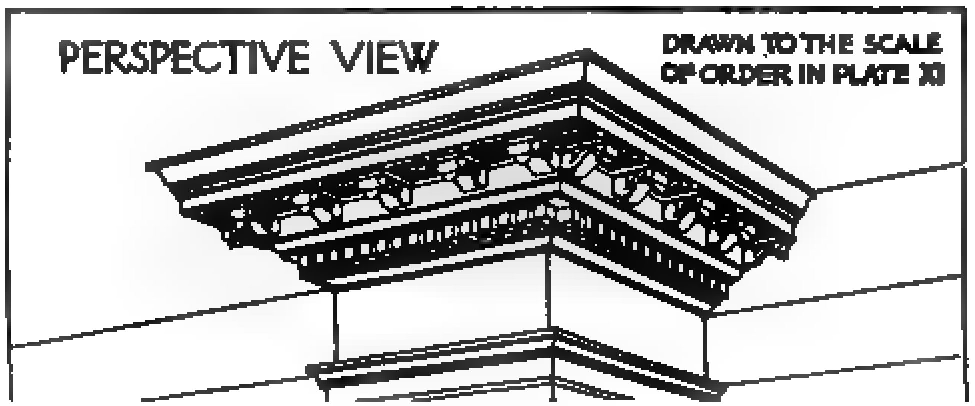


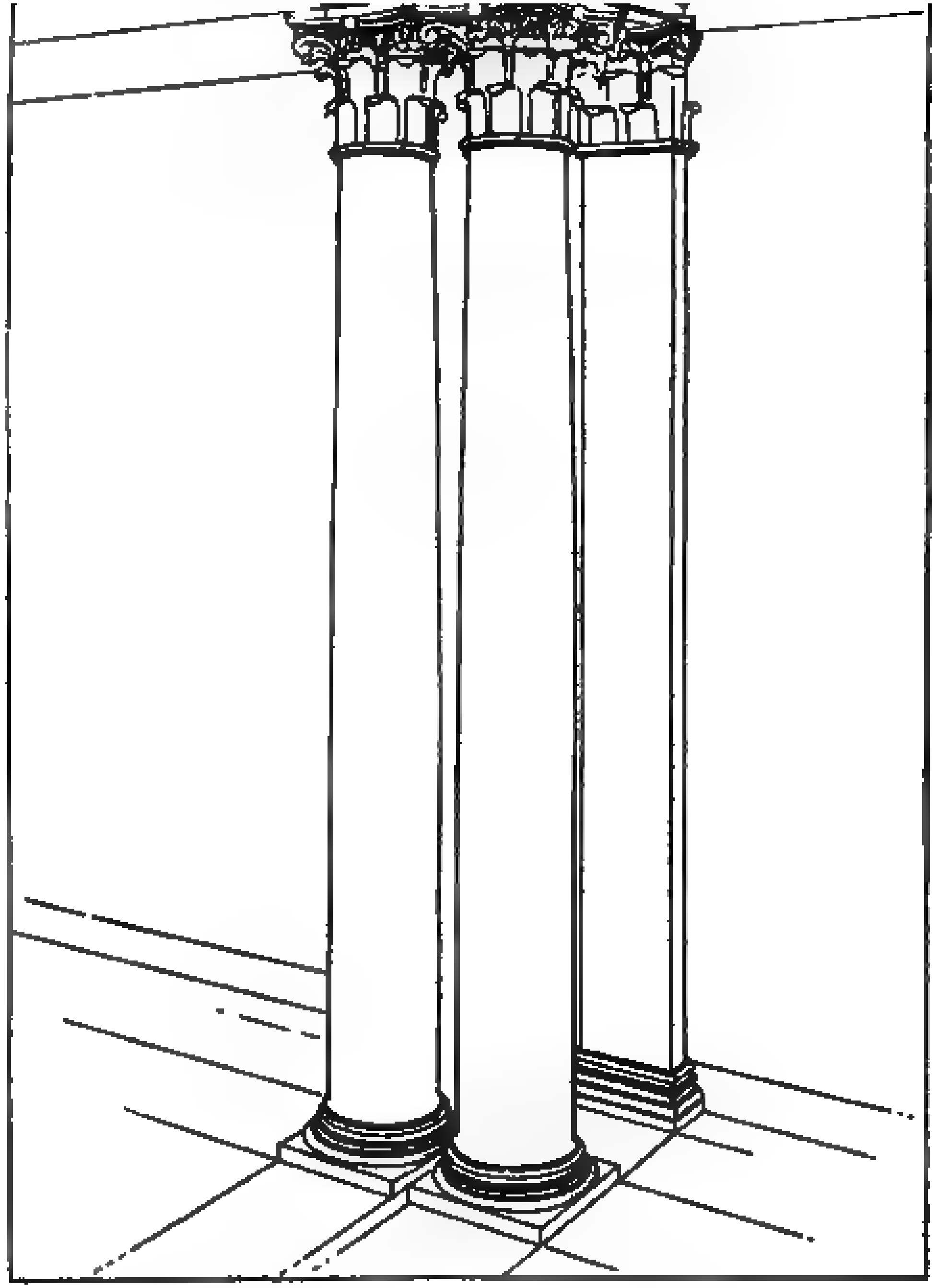
Fig. 22

CORINTHIAN ORDER



PLAN OF CAPITAL LOOKING UP





ELEVATION OF CAPITAL AND BASE

PLAN OF BASE

PLATE IX

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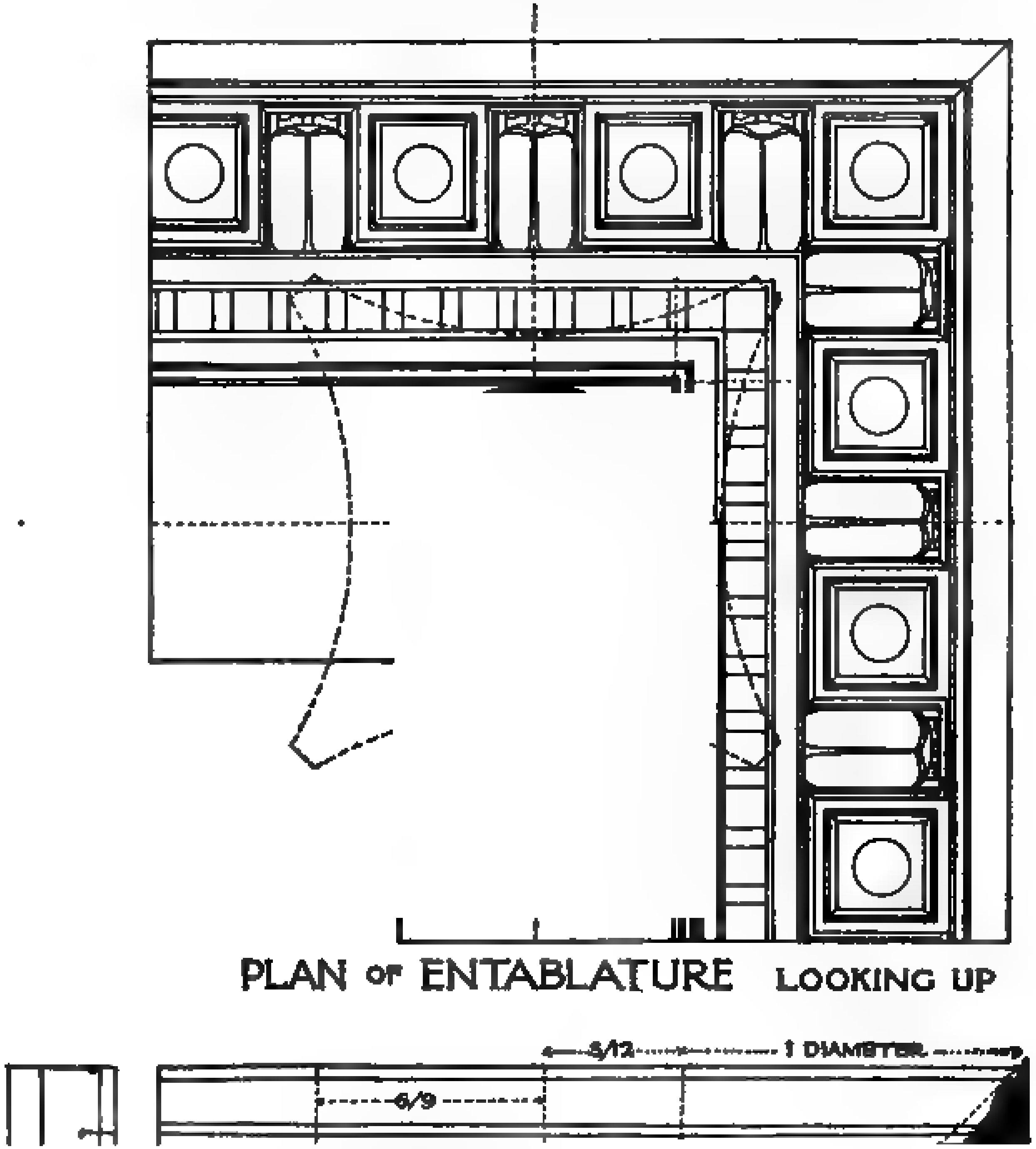
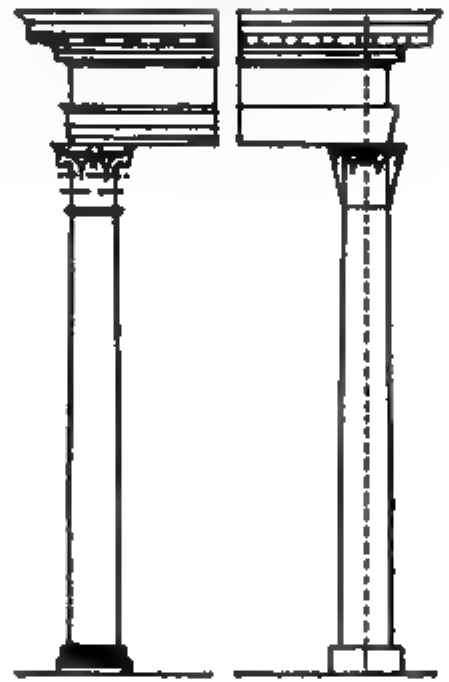
CORINTHIAN ORDER



PLAN OF ENTABLATURE LOOKING UP



BLOCK ORDER

COMPLETE ORDER

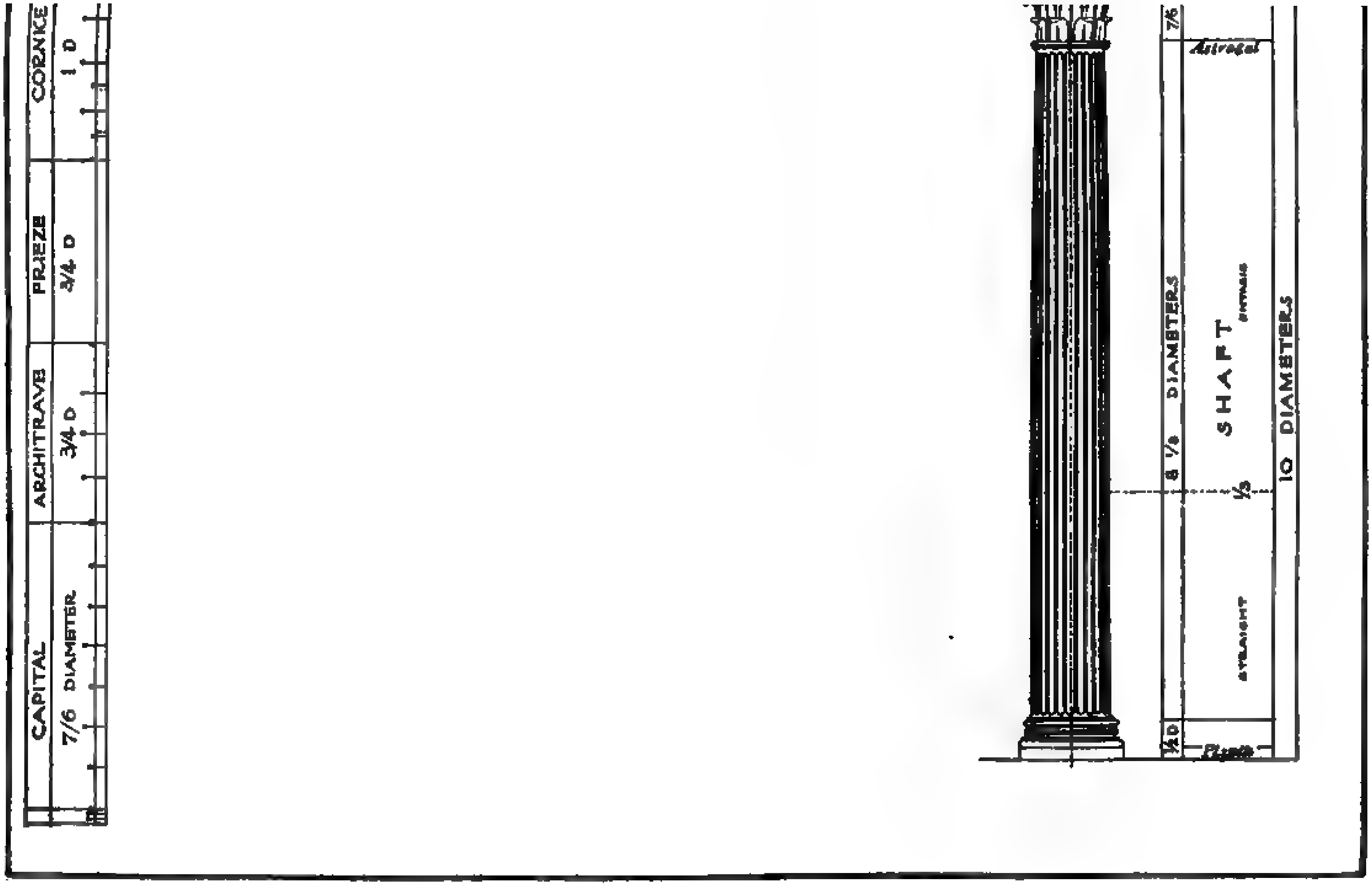


PLATE X

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CORINTHIAN ORDER—PLATES IX AND X

66. The three distinguishing characteristics of the **Corinthian order,** Plates IX and X, are a tall bell-shaped capital, a series of small brackets, called *modillions*, that support the cornice instead of mutules, in addition to the dentils, and a general richness of detail in both capitals and modillions, which is enhanced by the use of the *acanthus leaf* (see *History of Architecture and Ornament*, Part 1).

The height of the cornice, Fig. 32, is divided into five parts. The two lower and the two upper parts resemble the lower and upper halves of the Ionic cornice. The middle fifth is occupied by a *modillion band*, which carries the modillions, or brackets. These, as well as the modillion band, are crowned by a small cyma reversa. They consist of a double scroll, below which is an acanthus leaf. Each modillion is half a diameter long, one-fifth high, and as wide as a dentil and two interdentils; that is to say, two-ninths of a diameter. They are set two-thirds of a diameter on centers, one being over the axis of the corner column, and one over the outer face of the double dentil. The soffit of the corona between the modillions is occupied by a sinkage with moldings, called a *caisson*, in the middle of which there is a large *rosette*.

As the modillions are two-thirds of a diameter on centers, or four-sixths, and the dentils are one-sixth on centers, it follows that there are four dentils to each modillion; that is, a dentil under every modillion, and three between. As in the Ionic order and in the denticulated Doric, the last dentil, which is the first half of the double dentil, is centered over the face of the lower diameter of the column, as shown in Fig. 74 (*c*).

67. The architrave, which is three-quarters of a diameter high, has three bands and a large cymatium, which is as wide as the first band. The two lower bands occupy the lower half of the architrave, and the third band and the cymatium the upper. A small bead, or a small cyma reversa, generally

crowns each band. The frieze, which is also three-quarters of a diameter high, may be plain, pulvinated, or sculptured.

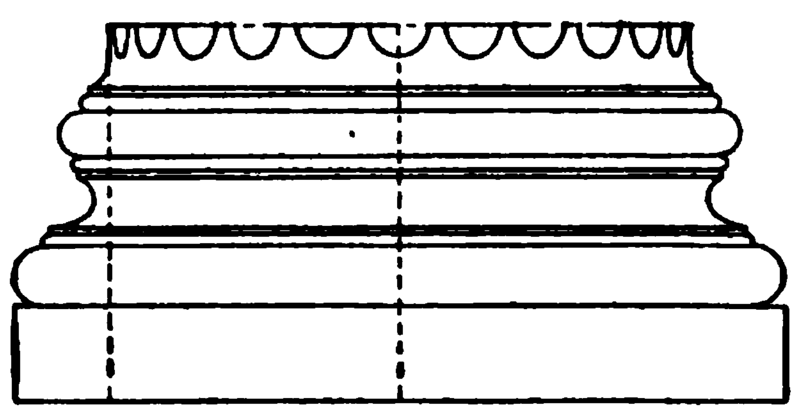
68. The capital is seven-sixths of a diameter high, the upper sixth being taken up by the abacus, which is nine-sixths, or a diameter and a half, in width, though it does not look so. It is molded on the edge with an ovolo and fillet above a large congé and small fascia. The corners are cut off at an angle of 45°, and the sides are hollowed out in a curve of 60°, as shown in Fig. 33 (*a*). The width across from curve to curve is seven-sixths of a diameter. Each face of the abacus bears a flower, called the *fleuron*, that springs from a small bud above the middle leaf.

(*a*) (*b*)

FIG. 33

The *bell* of the capital, Fig. 33 (*b*), is one diameter high, or six-sixths; it terminates under the abacus in a beak molding called the *lip of the bell*, which measures seven-sixths of a diameter across, its greatest projection coming just under the least projection of the upper line of the abacus. The lower two-sixths are covered by a row of eight acanthus leaves that bend down at the top to the extent of half a sixth, or a quarter of their own height. The next two-sixths show a similar row of eight leaves set alternately with those below, four facing the sides of the capital, and four the corners. Like those of the first row, they spring from the astragal at the top of the shaft, and the mid-rib of each

leaf shows between two lower leaves, it being really four-sixths high. These also bend down half a sixth. Between the eight leaves of the second row are eight *caulicoli*, or cabbage stalks, which terminate in a *button*, on which rests a sort of *bud*, which divides into two leaves. These turn right and left, the larger one toward the corner of the capital, the smaller toward the side or front under the fleuron. From each bud rise also two scrolls, or volutes, one of which runs out to support the projecting corner of the abacus. The other, which is smaller and does not rise higher than the lip of the bell, supports the fleuron. Sixteen leaves of a third row curl over under these sixteen volutes, making with them eight masses of ornament, one under each corner of the abacus, and one in the middle of each side. These give in



Palladio's Corinthian Base

FIG. 34

plan an eight-pointed star, each point consisting of a large leaf, two small leaves, two volutes, and above them either the fleuron or the horn of the abacus. Between them is seen the bell of the cap, with its lip.

69. Here, again, the Attic base is commonly used, but sometimes, especially in large columns, a base is used that resembles Vignola's Ionic base, with two beads between the scotias, except that it has a lower torus, as shown in Fig. 33. Palladio used a very elegant variety of Attic base, enriched by the addition of beads and fillets, as shown in Fig. 34. The shaft is fluted like the Ionic shaft, with twenty-four semicircular flutings, but these are sometimes filled with a convex molding, or *cable*, to a third of their height.

Almost all the buildings erected by the Romans employ the Corinthian order.

TABLE OF THE CORINTHIAN ORDER

$\frac{3}{4}\ D$ equals $\begin{cases}\text{height of architrave.}\\ \text{height of frieze.}\end{cases}$

$1\ D = \frac{4}{4}\ D$ equals $\begin{cases}\text{height of cornice.}\\ \text{projection of cornice.}\end{cases}$

$\frac{1}{6}\ D$ equals $\begin{cases}\text{projection of plinth.}\\ \text{height of plinth.}\\ \text{height of lower band.}\\ \text{height of dentils.}\\ \text{distance of dentils, o. c.}\end{cases}$

$\frac{1}{3}\ D = \frac{2}{6}\ D$ equals $\begin{cases}\text{height of leaves.}\\ \text{projection of abacus.}\end{cases}$

$\frac{1}{2}\ D = \frac{3}{6}\ D$ equals length of modillions.

$\frac{2}{3}\ D = \frac{4}{6}\ D$ equals $\begin{cases}\text{distance of modillions, o. c.}\\ \text{distance from axis to face of double dentil.}\end{cases}$

$\frac{5}{6}\ D$ equals upper diameter.

$1\ D = \frac{6}{6}\ D$ equals $\begin{cases}\text{lower diameter.}\\ \text{height of bell.}\\ \text{height of cornice.}\\ \text{projection of cornice.}\end{cases}$

$\frac{7}{6}\ D$ equals $\begin{cases}\text{height of capital.}\\ \text{width of abacus (least).}\\ \text{width of lip of the bell.}\end{cases}$

$1\frac{1}{3}\ D = \frac{8}{6}\ D$ equals width of plinth.

$1\frac{1}{2}\ D = \frac{9}{6}\ D$ equals width of abacus (greatest).

$2\ D = \frac{12}{6}\ D$ equals width of abacus (diagonal).

$\frac{1}{9}\ D$ equals width of dentil.

$\frac{2}{9}\ D$ equals width of modillion.

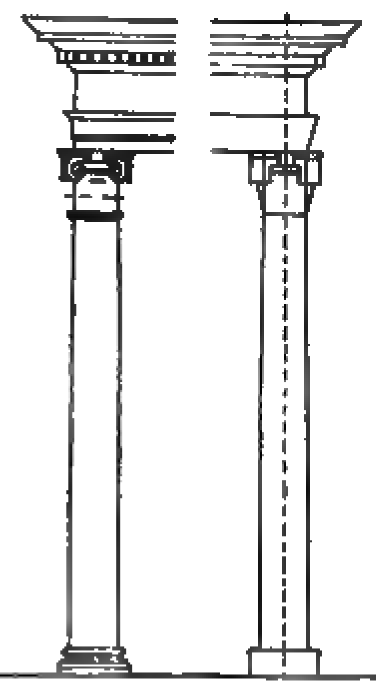
$\frac{1}{18}\ D$ equals width of interdentil.

$\frac{1}{12}\ D$ equals $\begin{cases}\text{height of astragal.}\\ \text{projection of astragal.}\end{cases}$

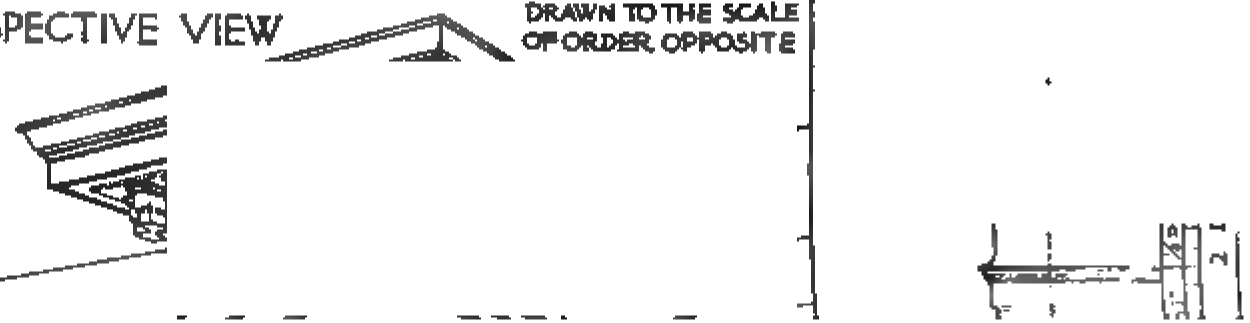
$\frac{1}{6}\ D$ equals height of modillion.

COMPOSITE ORDER

AFTER VIGNOLA



AFTER PALLADIO



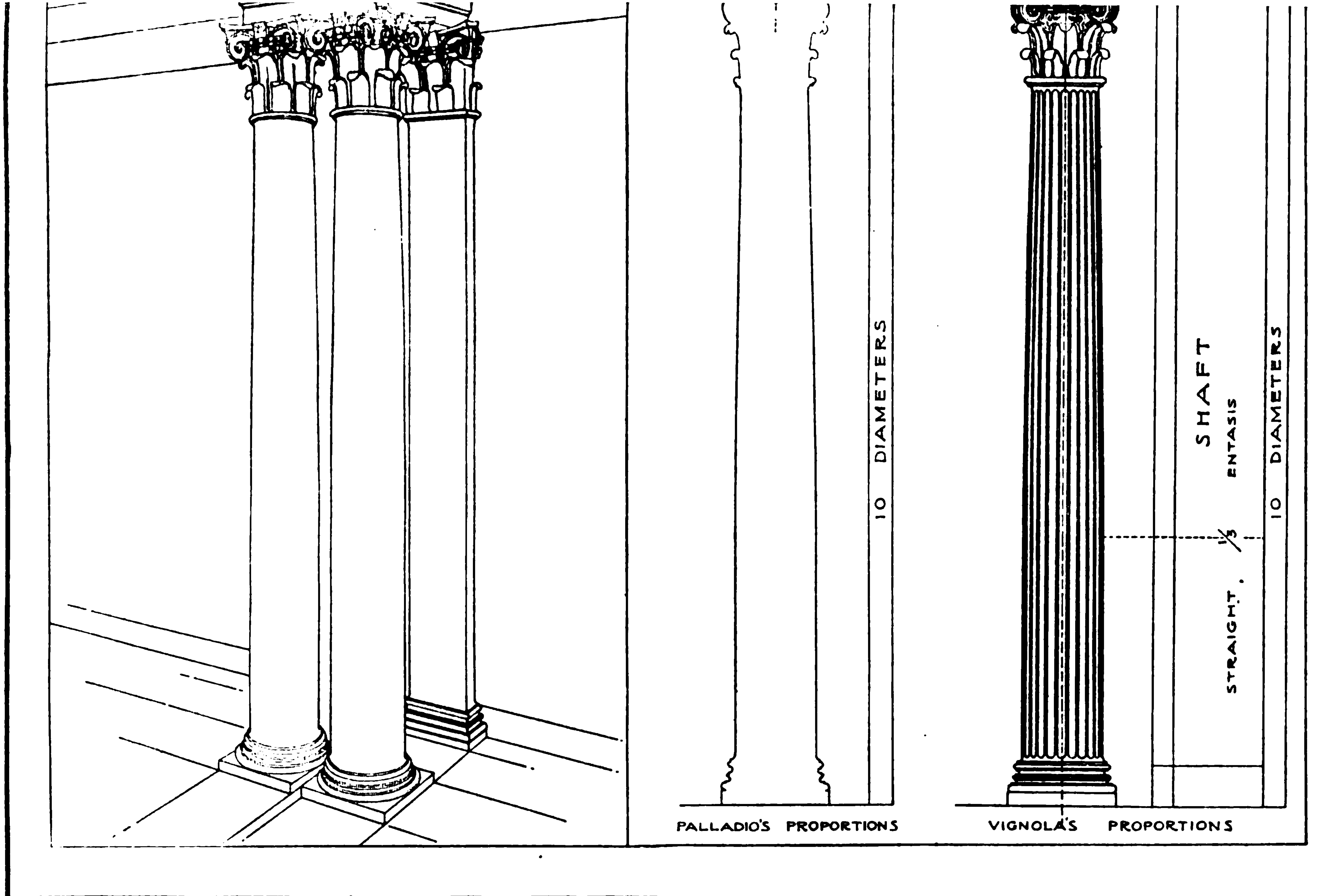


PLATE XI

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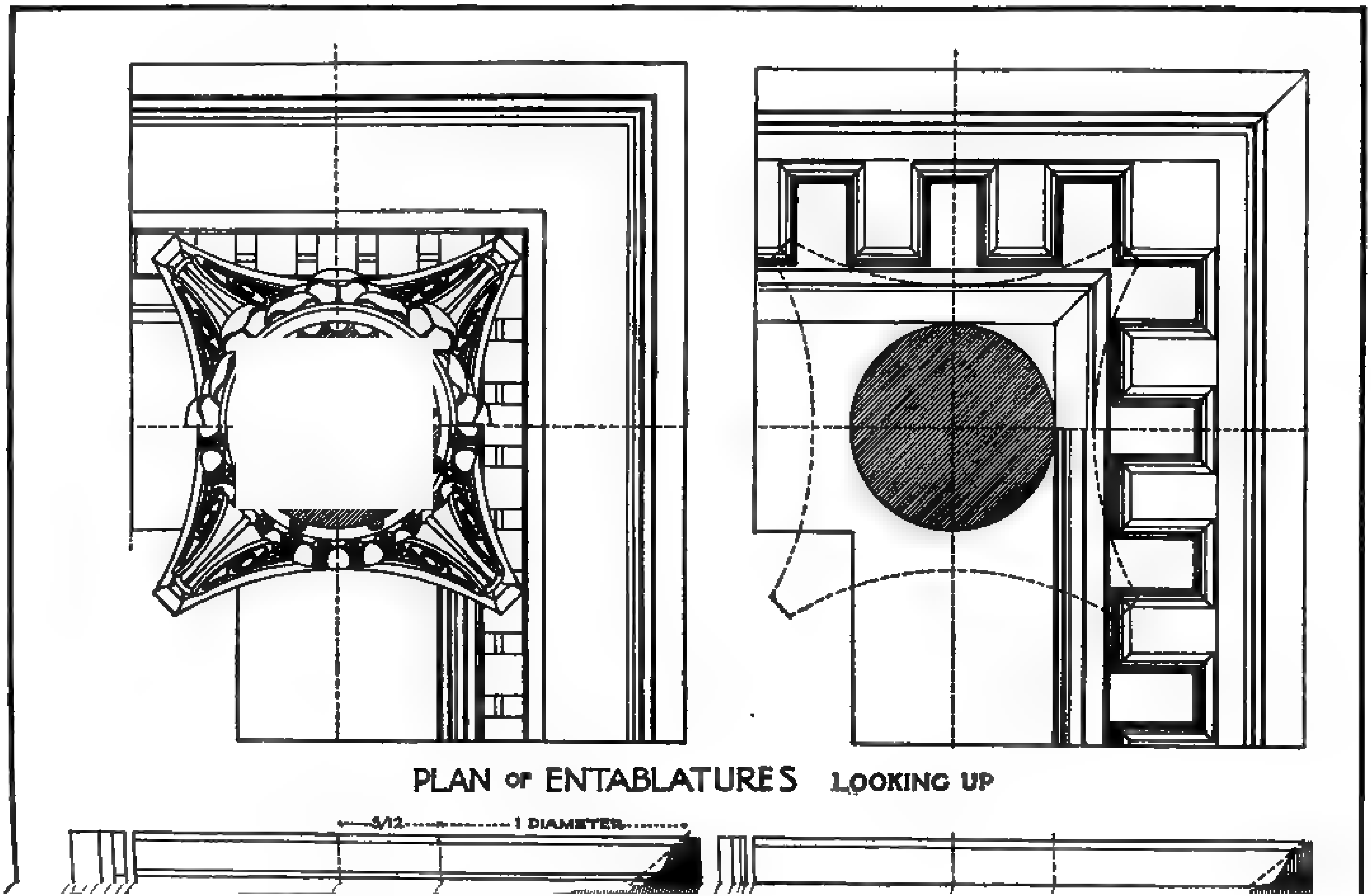
COMPOSITE ORDER



PLAN OF ENTABLATURES LOOKING UP

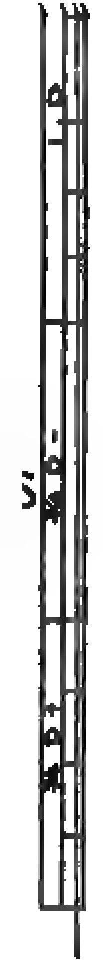


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PLATE XII

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COMPOSITE ORDER—PLATES XI AND XII

70. **The Composite order,** Fig. 35, is a heavier Corinthian, just as the Tuscan is a simplified Doric. The chief

FIG. 35

proportions are the same as in the Corinthian order, but the details are fewer and larger. It owes its name to the capital, Fig. 35, in which the two lower rows of leaves and the

caulicoli are the same as in the Corinthian. But the caulicoli carry only a stunted leaf bud, and the upper row of leaves and the sixteen volutes are replaced by the large

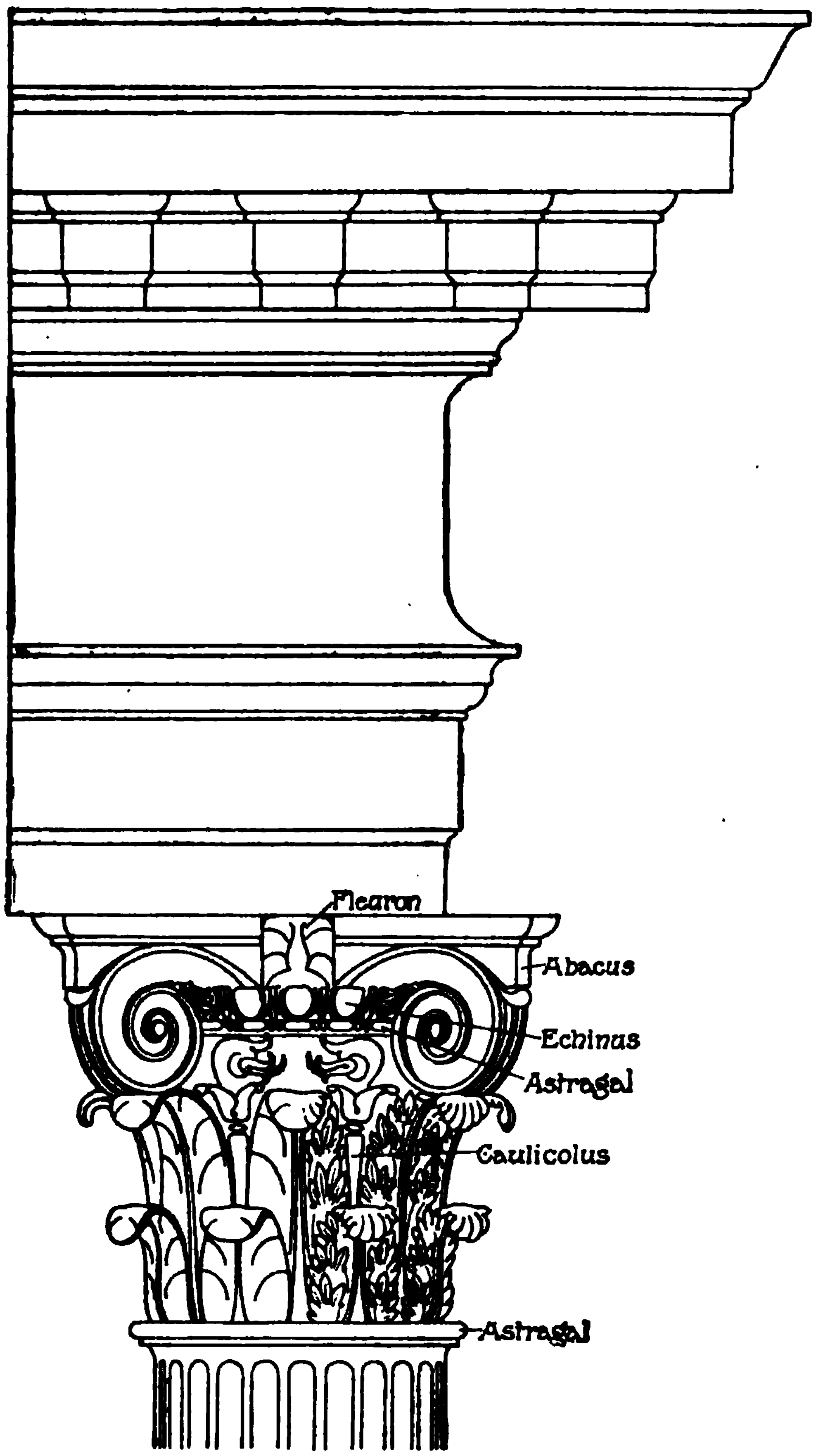


FIG. 36

scrolls, echinus, and astragal of a complete Ionic capital, with four faces like Scamozzi's, Fig. 31 (*d*). A composite capital thus has two astragals, if the lower be included, but

this properly belongs to the shaft. The scrolls are nearly half a diameter high, covering up half the abacus and coming down so as to touch the second row of acanthus leaves. They measure fully nine-sixths across, and are only three-sixths apart, or half a diameter, instead of four-sixths, as in the Ionic.

71. Vignola's composite entablature, Fig. 36, differs from his Ionic chiefly in the shape and size of the dentils. They are larger, and are more nearly square in elevation, being a fifth of a diameter high, and one-sixth wide, the interdentil being one-twelfth, and they are set one-fourth of a diameter apart, on centers. The last dentil, or first half of the double dentil, is centered over the outer face of the column, at the bottom, as in the Corinthian, Ionic, and denticulated Doric, Fig. 42. The outer face of the double dentil is three-quarters of a diameter from the axis of the column, and there is only one dentil between the double dentil and the one over the axis, against two in the Corinthian and Ionic, and three in the denticulated Doric. The frieze terminates in a large congé over the architrave, and the corona is undercut with a large quirked cyma recta, making a drip.

72. Palladio's Composite entablature, Fig. 36, is more characteristic than Vignola's, the parts being fewer and larger. The architrave has two bands, the frieze terminates in two large congés, and the cornice is divided into two equal parts, each half a diameter high. The upper half is shared about equally by the cymatium and the corona, and the lower half is almost entirely taken up by a series of large brackets, or blocks, a third of a diameter high and one-fourth wide, divided into two bands. The inner face of the double block comes just in line with the frieze below, as shown in Fig. 47. The bands and moldings that decorate the blocks are continued between them.

These dimensions apply the Palladio entablature where it is made of the same size as Vignola's; that is to say, a quarter of the height of the column, or two diameters and a

half. But Palladio himself made his Composite entablature only two diameters high, or one-fifth the length of the column, cutting down the frieze to half a diameter, the architrave to two-thirds, and the cornice to five-sixths. If the dimensions of Palladio's cornice given in the table are, accordingly, taken from the upper diameter of the shaft instead of from the lower, they will exactly conform to Palladio's own usage.

73. The block entablature used by Scamozzi for his Composite order is even less than two diameters in height, and this seems to have been the case also with the entablature of the Olympiæum at Athens, which Palladio is thought to have imitated.

The moldings below the blocks are often made to project more than in Palladio's example. This increases their distance apart, on centers, since one must still come over the axis of the column and the one on the corner must be as far out as the end of these moldings. The blocks also vary considerably in length in different examples.

The upper part of the Composite capital, as has been said, is often used alone as a variety of the Ionic capital.

The Composite capital is employed in the Arch of Titus in Rome, and elsewhere, with a Corinthian entablature, and the block cornice occurs in the so-called frontispiece of Nero, as well as in the temple at Athens, in connection with a Corinthian capital.

TABLE OF THE COMPOSITE ORDER

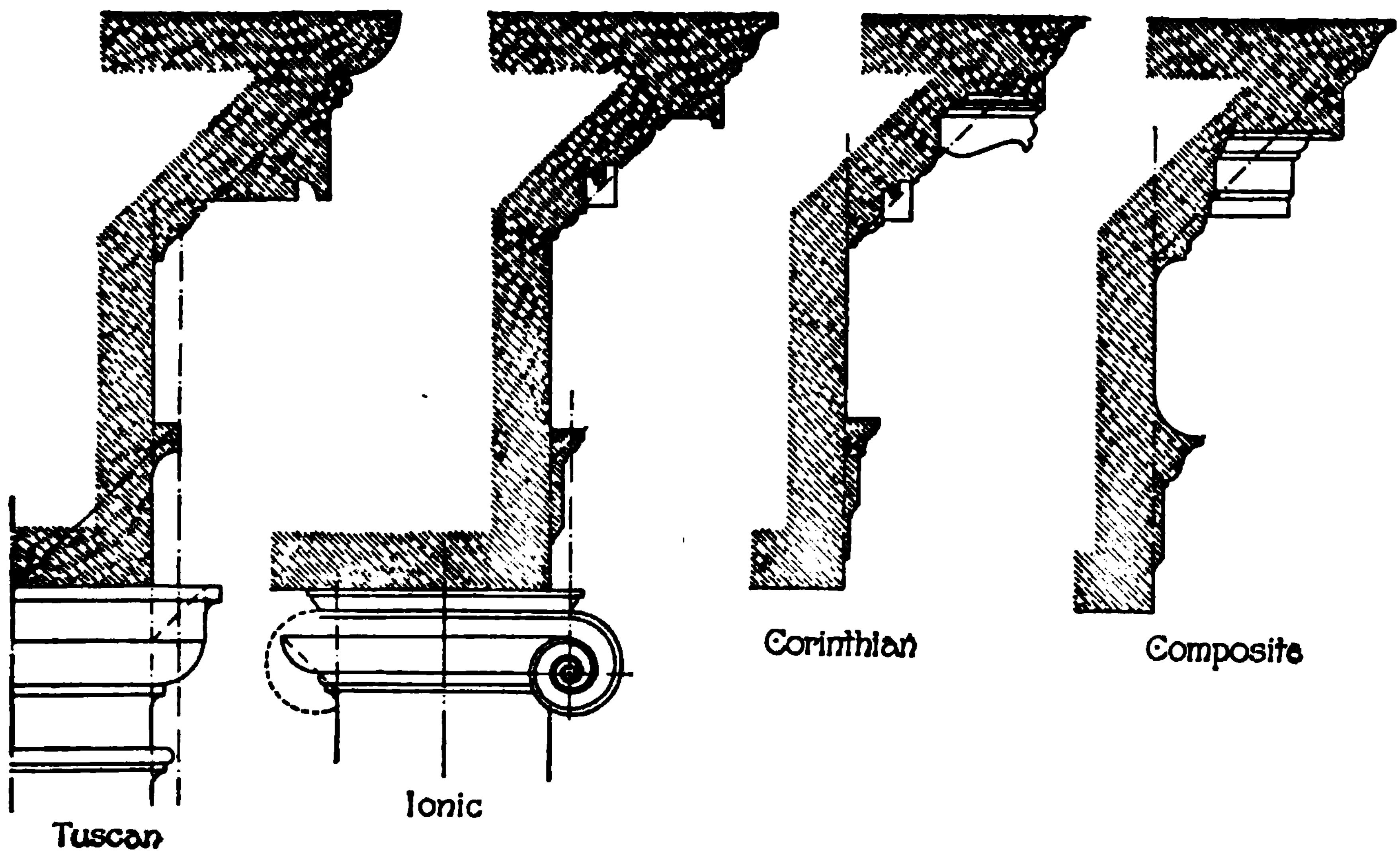
$$\tfrac{1}{2}\,D = \tfrac{3}{6}\,D \text{ equals} \begin{cases} \text{height of scrolls.} \\ \text{space between scrolls.} \end{cases}$$

$$\tfrac{3}{4}\,D \text{ equals distance of eyes, o. c.}$$

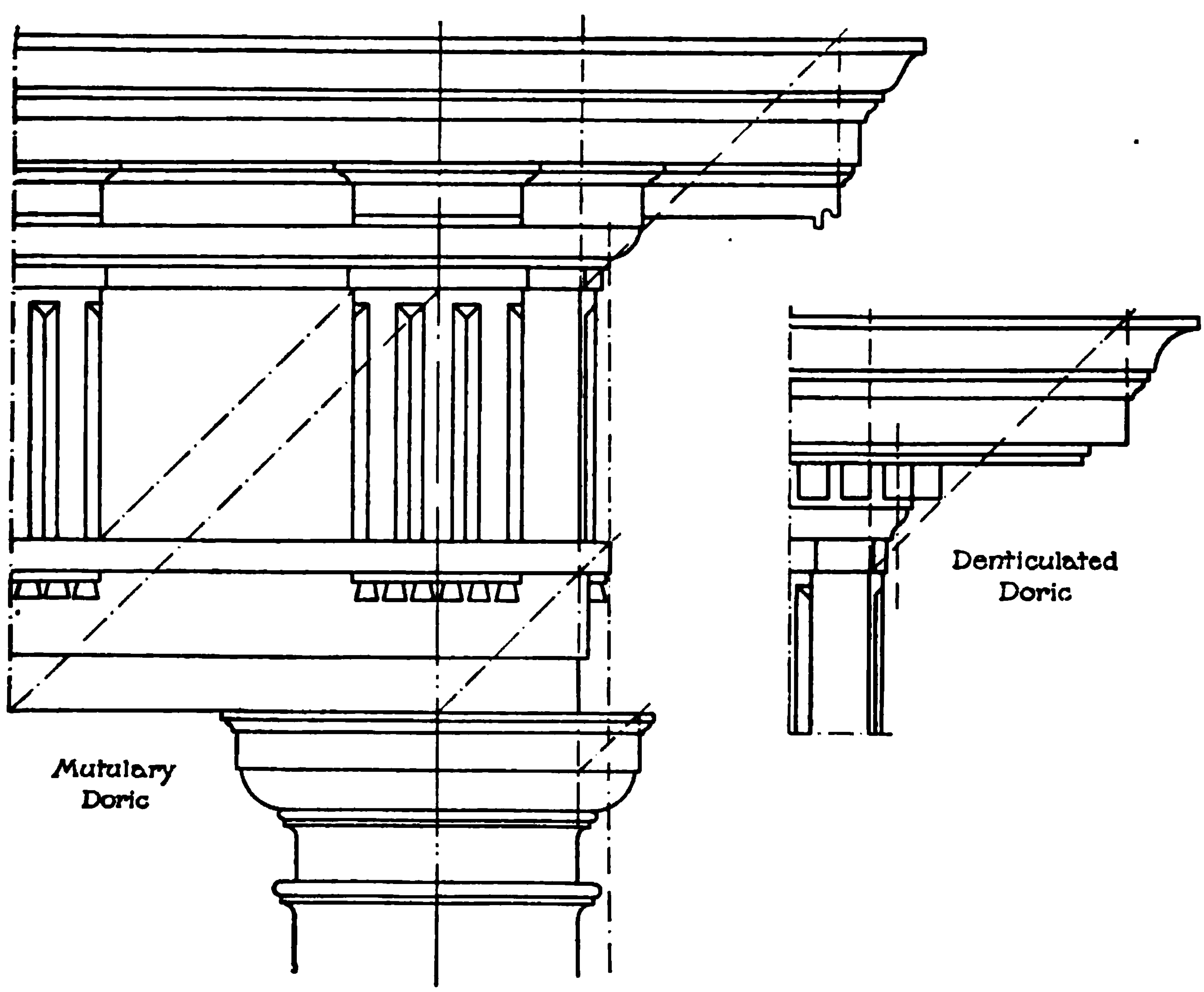
$$1\tfrac{1}{2}\,D = \tfrac{9}{6}\,D \text{ equals} \begin{cases} \text{width of scrolls.} \\ \text{width of plinth.} \\ \text{width of abacus.} \end{cases}$$

VIGNOLA'S CORNICE

$$\tfrac{1}{4}\,D \text{ equals} \begin{cases} \text{height of dentil band.} \\ \text{distance of dentils on centers.} \end{cases}$$


Corinthian
Composite
Ionic
Tuscan

(a)


Denticulated
Doric
Mutulary
Doric

(b)

FIG. 87

$\frac{3}{4}$ D equals distance from axis to face of double dentil.

$\frac{1}{6}$ D equals height of dentils.

$\frac{1}{9}$ D equals width of dentils.

$\frac{1}{18}$ D equals width of interdentil.

PALLADIO'S CORNICE

$\frac{1}{6}$ D equals $\begin{cases} \text{height of block.} \\ \text{length of block.} \end{cases}$

$\frac{1}{4}$ D equals $\begin{cases} \text{width of block.} \\ \text{height of lower band.} \\ \text{height of corona.} \\ \text{height of cymatium.} \\ \text{distance between blocks (plus).} \end{cases}$

GEOMETRICAL RELATIONS

74. The dimensions and proportions set forth in the preceding paragraphs, and recapitulated in the tables, will enable the draftsman or the designer to draw the five orders, according to Vignola, with great accuracy and sufficiently in detail for all ordinary purposes. The figures for the larger features are easily remembered, and the smaller divisions and subdivisions can for the most part be obtained by dividing the larger into two, three, four, or five equal parts.

But besides these arithmetical proportions some geometrical relations may be pointed out, which are calculated greatly to facilitate the work of draftsmanship, drawing being naturally more closely related to geometry than to arithmetic.

75. Lines at 45 Degrees.—The proportions of any figure that is as wide as it is high, and which can accordingly be included within a square, are most easily determined by drawing the diagonal of the square; that is to say, by drawing a line with a 45° triangle. Such figures are, as is shown in the illustrations, the projections of:

1. The echinus, in the Tuscan, Doric, and Ionic capitals, as in Fig. 37.

2. The abacus, in the Tuscan and Doric capitals.

3. The astragal, in all the orders.

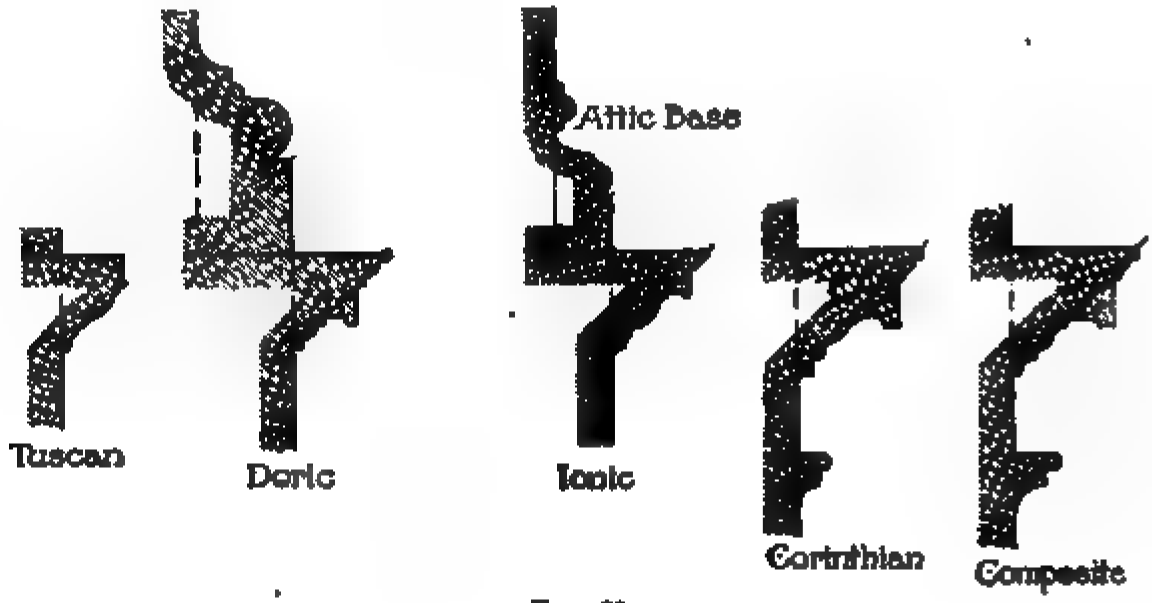


Fig. 38

4. The architrave, including the tænia, in the Tuscan and Doric orders, counting from the axis of the column.

5. The tænia itself, and the cymatium that takes its place.

6. All the cornices, except the Doric.

76. A line drawn at 45° through the Doric cornice from the top of the frieze gives, where it cuts the upper line of the cornice:

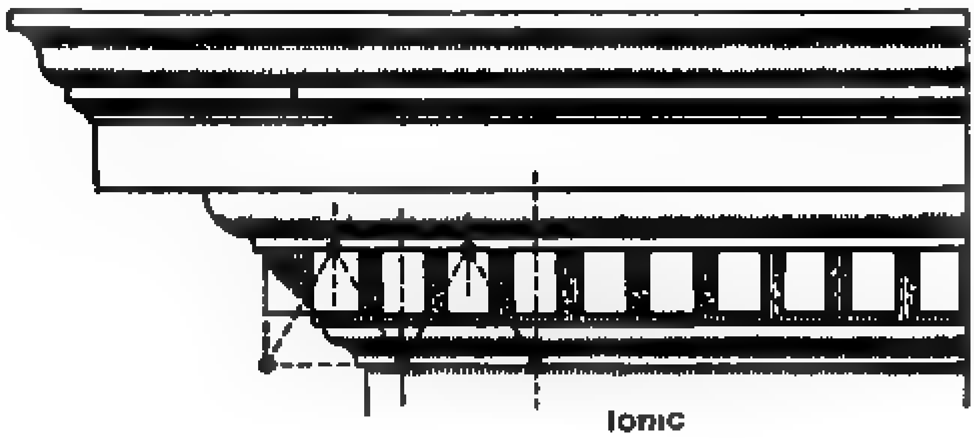
Fig. 39

1. The face of the corona, in the denticulated Doric, as in Fig. 37.

2. The face of the mutule in the mutulary Doric, as in Fig. 37.

A line drawn at 45° through the Doric architrave and frieze, from a point on the axis of the column and of the triglyph, taken either at the bottom of the architrave or at the top of the frieze, gives the axis of the next triglyph, and so on.

A 45° line also gives:



(a)

(b)

Fig. 40

1. The shape of the metope.
2. The caps of the pedestals, except the Tuscan, as in Fig. 38.
3. The plinths of the Doric and Attic bases.

Lines drawn at an angle of 45° across the Corinthian capital from the extremities of its lower diameter give the width of the abacus, as in Fig. 39.

Where they cut the line of the upper diameter of the shaft, extended, they give the depth of the scroll, as in Fig. 39.

77. Lines at 60 Degrees.—In a similar manner, lines drawn at an angle of 60° through the bed mold of the Ionic cornice from a point on the axis of the column, taken either on the upper line of the frieze or on the upper edge of the dentil band, give, where they touch the upper line of the frieze and the upper line of the dentil band, the axes of the dentils, and the outer face of the double dentil, as shown in Fig. 40 (*a*).

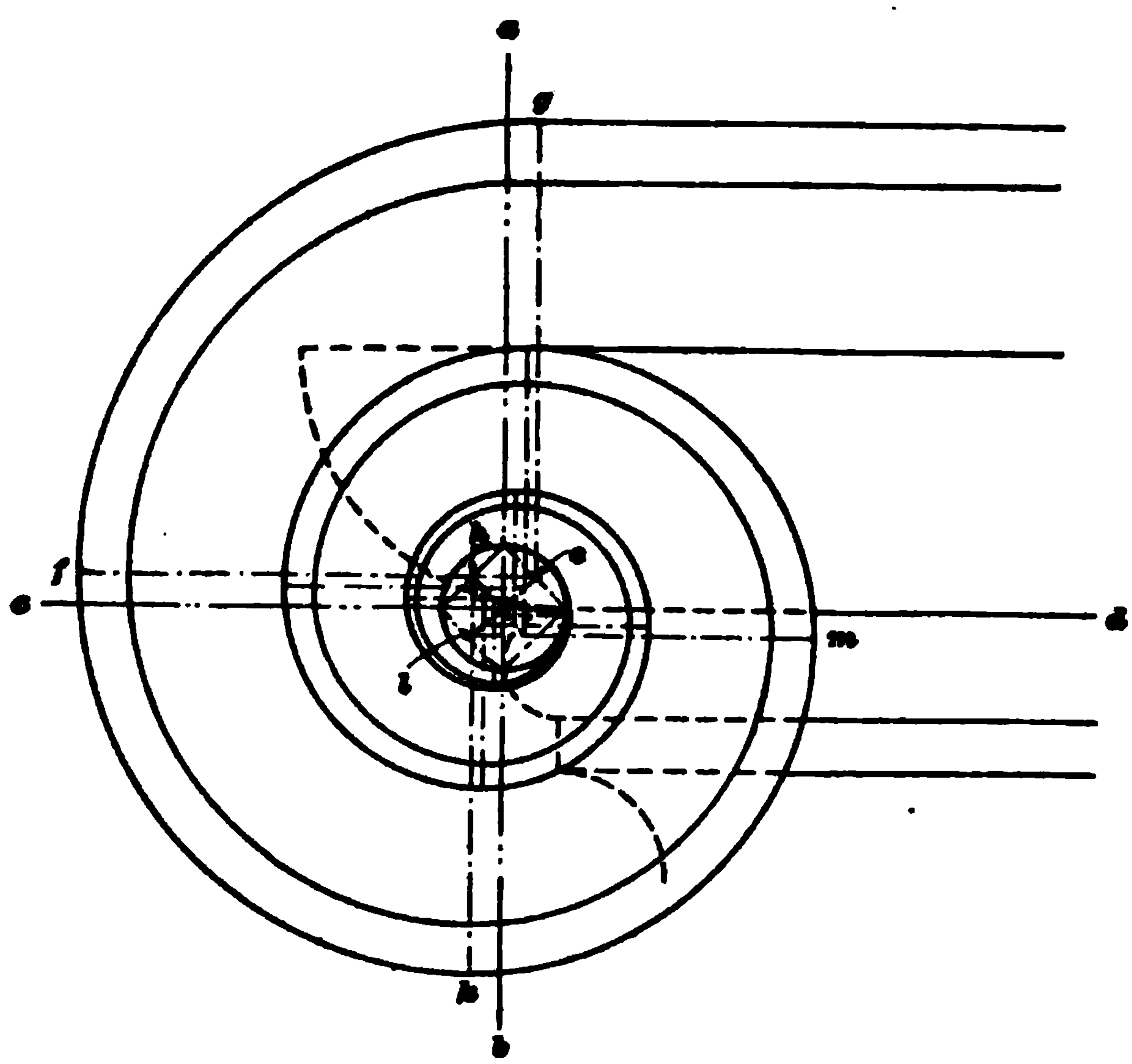


FIG. 41

Similar lines drawn at 60° in the Corinthian cornice, taken from a point where the axis of the column cuts the lower edge of the corona, give: (1) where they cut the lower edge of the corona, the upper line of the frieze, and the lower line of the ovolo, the axes of the modillions and of the dentils, and the outer face of the double dentil, very nearly, as in Fig. 40 (*b*); (2) where they cut the lower line of the modillion band, the width of the modillion, and the outer face of the modillion band, as in Fig. 40 (*b*).

The distance from the edge of the corona down to the lower edge of the modillion band is one-third the distance

down to the top of the frieze, and the distance down to the lower edge of the ovolo, one-half.

78. Ionic Volute.—The vertical line *a b*, Fig. 41, through the center of the eye of the Ionic volute, and the horizontal line *c d*, will mark in the circumference of the eye the four corners of a square within which a fret may be drawn whose angles will serve as centers, from which the curves of the volute may be described mechanically. The sides of the square should be bisected, and through the upper points thus located a horizontal line *e f* should be drawn. Now, with *e g* as a radius, the arc *g f* may be drawn as the first section of the volute. Now, through the point *h*, where the line *e f* bisects the side of the square, a vertical line *h k* should be drawn, and with *h f* as a radius the arc *f k* may be struck. From *h* and *e* lines should be drawn at 45°, intersecting at the center of the eye, and the line extending from *h* to the center should be divided into three equal parts, through which the corners of the inscribed fret will turn. The point *l* on the line *h k*, marking the lower left-hand corner of the inscribed fret, is located five-sixths of the distance between *h* and the point where *h k* bisects the lower side of the square. The point *l* then forms the center for the arc *k m*, and the rest of the volute is described from centers found at the angles of the inscribed fret.

79. Vertical Lines.—The outer line of the upper diameter of the shaft gives, in all the orders, Fig. 37, the face of the lower band of the architrave, and the face of the frieze.

In the denticulated Doric, it gives, as in Fig. 37, the outer face of the first dentil, next the double dentil.

In the Ionic and Corinthian orders, it gives the axis of the first interdentil.

The outer line of the lower diameter of the shaft, produced upwards, gives, as in Fig. 37:

1. The projection of the astragal, in all the orders, except the Tuscan and Doric.
2. The projection of the tænia, in the Tuscan and Doric.

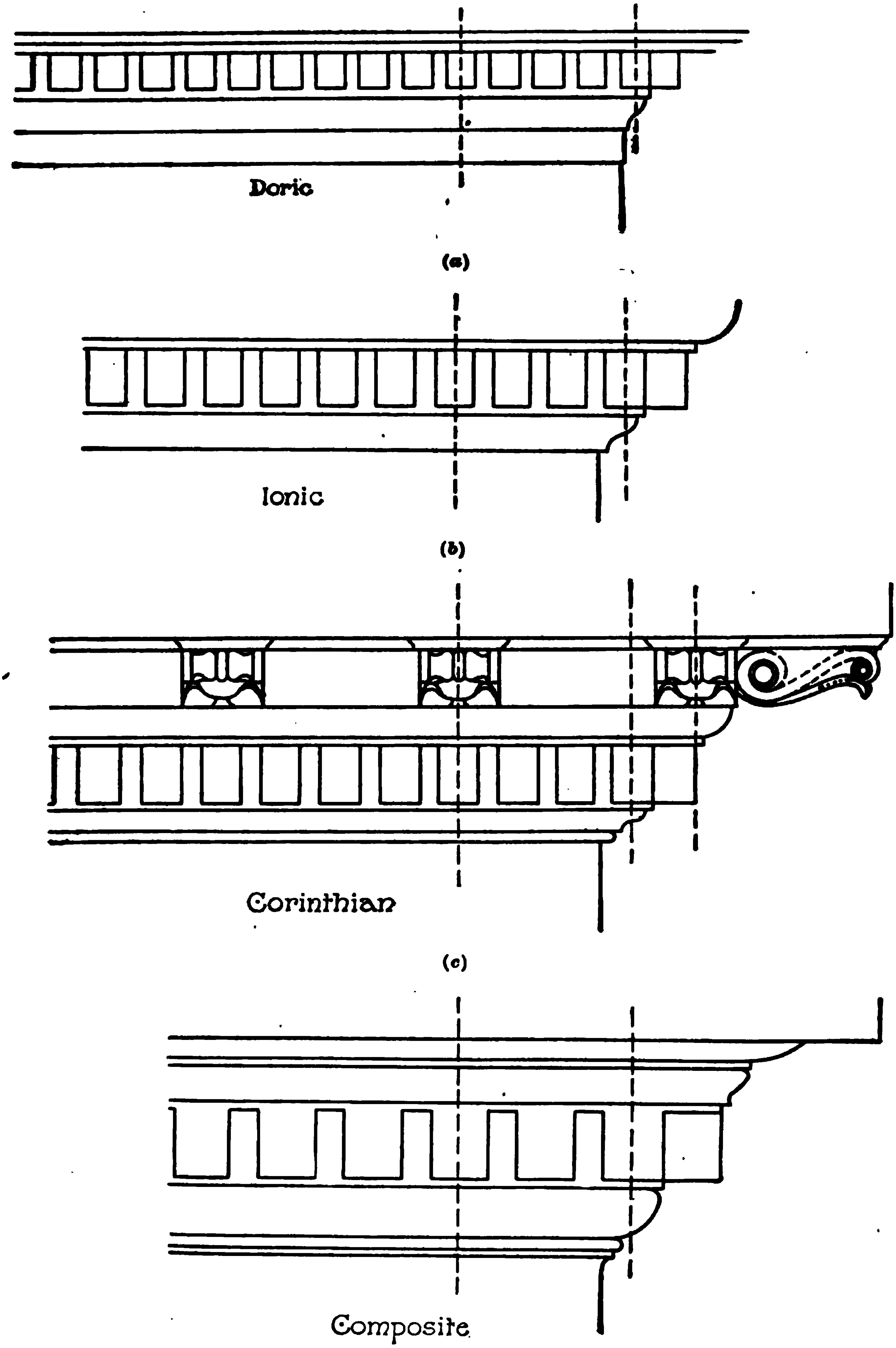
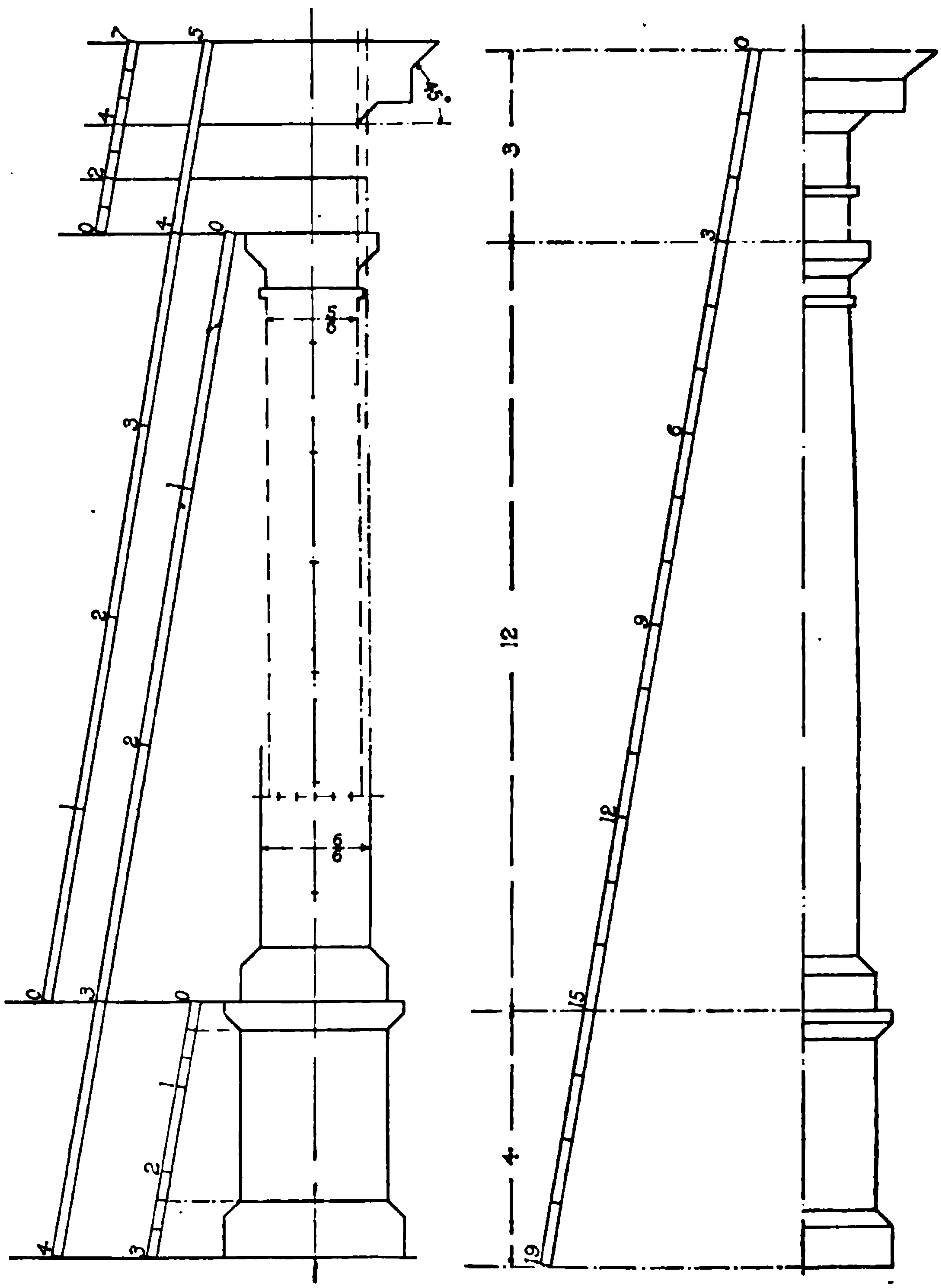


Fig. 42



(a) (b)

Fig. 48

3. The projection of the fillet, in the bed mold of the mutulary Doric.

4. Twice the projection of the triglyph, which is seen in profile.

5. Half the projection of the Tuscan bed mold, of the Tuscan and Doric abacus, and of the Doric mutule band.

It also gives the axis of the extreme dentil, or first half of the double dentil, in the denticulated Doric, Ionic, Corinthian, and Composite orders, as shown in Fig. 42, and the position of the eye of the Ionic scroll, which is on a level with the bottom of the echinus, as in Fig. 41.

DRAWING

80. General Proportions.—Since the relative size of all the parts in Vignola's orders is fixed, any of them can be drawn out in accordance with these rules, if a single dimension is determined. The width of a dentil or the length of a modillion suffices to determine everything else. But the data generally given are either the lower diameter of a column, the height of a column, or the whole height of the order, with or without a pedestal.

81. If the lower diameter is given, the procedure is as follows: Divide the diameter in two, draw the axis of it, and then divide each half into three equal parts, as shown in Fig. 49 (*a*); this gives the scale of sixths. Divide in two the two outer sixths; this gives the upper diameter of the shaft, which is five-sixths. Lay off on the axis the height of the column—by diameters, 7, 8, 9, or 10, according to the order—and of the entablature, which is one-fourth the height of the column. Mark the height of the base, half a diameter, or three-sixths, and then that of the capital, two-, three-, or seven-sixths.

Then divide the total height of the entablature into seven, eight, eighteen, or ten equal parts, according as it is Tuscan, Doric, Ionic, or Corinthian, or use halves, quarters, or eighths of a diameter, and mark the heights of the archi-

trave, frieze, and cornice, drawing horizontal lines through the points of division. [Fig. 43 (*a*) illustrates this procedure for the Tuscan order.] Then carry up, vertically, the outer lines of both the upper and the lower diameters of the shaft, drawing from the point where the line of the upper diameter cuts the lower edge of the cornice a line at 45°, to determine the projection of the cymàtium or that of the mutule or of the corona.

Add one-third of the height of the column for the pedestal. Divide this into nine equal parts, taking the upper ninth for the cap, and the lower two-ninths for the base. Vignola makes the base of the pedestal only one-ninth of the height of the pedestal instead of two-ninths as here determined.

82. If the height of the column is given, a fourth part of this added at the top gives the height of the entablature, and a third part added below gives the height of the pedestal, as shown in Fig. 43 (*a*). One-seventh, one-eighth, one-ninth, or one-tenth of the height of the column gives the lower diameter of the shaft. The drawing may then be carried forwards as just stated.

83. If the total height of the order is given, without the pedestal, a division into five equal parts gives four parts for the column and one for the entablature, as in Fig. 43 (*a*).

If there is a pedestal, and it is of the regular height of one-third the height of the column, the division of the total height must be into nineteen equal parts, four of which go to the pedestal, twelve to the column, and three to the entablature, as in Fig. 43 (*b*).

The lower diameter can then be obtained from the height of the column, and the drawing completed, as before.

NOTE.—The division of a given dimension into equal parts may be effected with the dividers, or, more easily, by using a scale of equal parts that are the same in number as the desired subdivisions, but a little larger, and holding this scale obliquely between the extreme limits of the space to be divided, as shown in Fig. 43. The division of vertical dimensions into five, seven, eight, nine, ten, eighteen, or nineteen equal parts, as here required, is thus easily accomplished. To insure accuracy, the lines marking these divisions should be horizontal, not at right angles to the direction of the scale.

84. Cornices.—The Tuscan cornice may be drawn by dividing its height into quarters, as is done in Fig. 44, giving the upper quarter to the ovolo and the lower to the bed mold, and the middle half to corona, bead, and fillet. A 45° line gives the projection of the bed mold, ovolo, and the cornice itself.

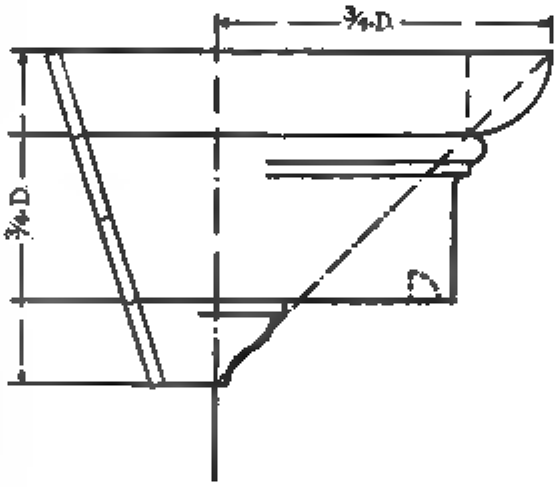


FIG. 44

The Doric cornice is also divided into four equal parts, the upper one comprising the cymatium and fillet, the next the corona and the small cyma reversa above it, the third the mutules (or the dentils with the mutules above them), and the lower one the bed mold, including the cap of the triglyph, which is narrower in the mutulary Doric than in the denticulated by the width of the fillet above it, as shown in Fig. 45.

(a)

FIG. 45

A 45° line drawn outwards from the middle of the top of the abacus gives, where it cuts the lower line of the frieze, the projection of the tænia. A similar line, where it cuts

the upper line of the frieze, gives the axis of the next triglyph, as in Fig. 37. The triglyphs, with their cap, are drawn next, and the regula and guttæ, then the mutules, or the dentils.

85. In the Doric order, a line of 45° drawn from the bottom of the cornice gives the face of the corona in the denticulated Doric, the face of the mutule in the mutulary; in the other orders, a similar line gives the projection of the cymatium, as in Fig. 45.

In putting in dentils, draw first the one over the axis of the column, then the double dentil, the first half of which is centered over the lower face of the column, and then the intermediate ones, three, two, or one, according as the order is Doric, Ionic, Corinthian, or Composite, as in Fig. 42. The interdentil is half the width of the dentil except in the Composite.

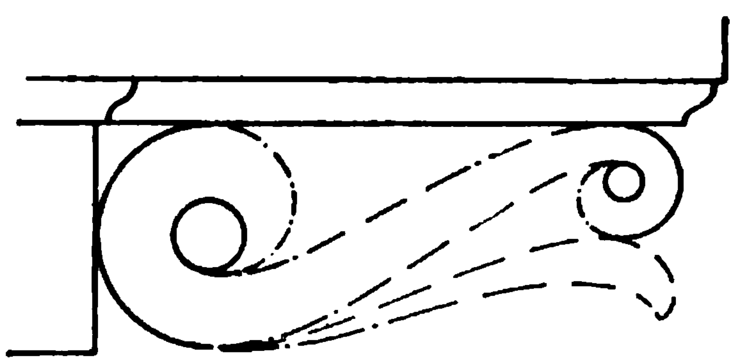
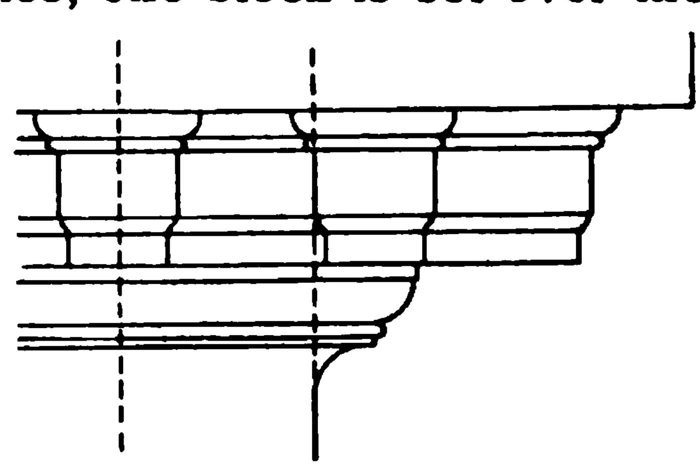


FIG. 46

One Corinthian modillion comes over the axis of the corner column and one over the outer face of the double dentil, as in Fig. 42 (*c*). In drawing the side of a modillion, put in first, at the outer end, a semicircle half its height and one at the inner end nearly the whole height; then the rosettes, one twice as large as the other; then the connecting curves; and finally the leaf beneath, as shown in Fig. 46.

In Palladio's Composite cornice, one block is set over the axis of the column, and the double block at the corner has its inner face on a line with the face of the frieze below. The blocks are about half a diameter on centers, the interblock being one-twenty-fourth of a diameter wider than the block itself, as shown in Fig. 47.



Composite

FIG. 47

86. Architraves.—The Tuscan architrave has only one fascia, or band, as shown in Fig. 48 (*a*); the Composite two,

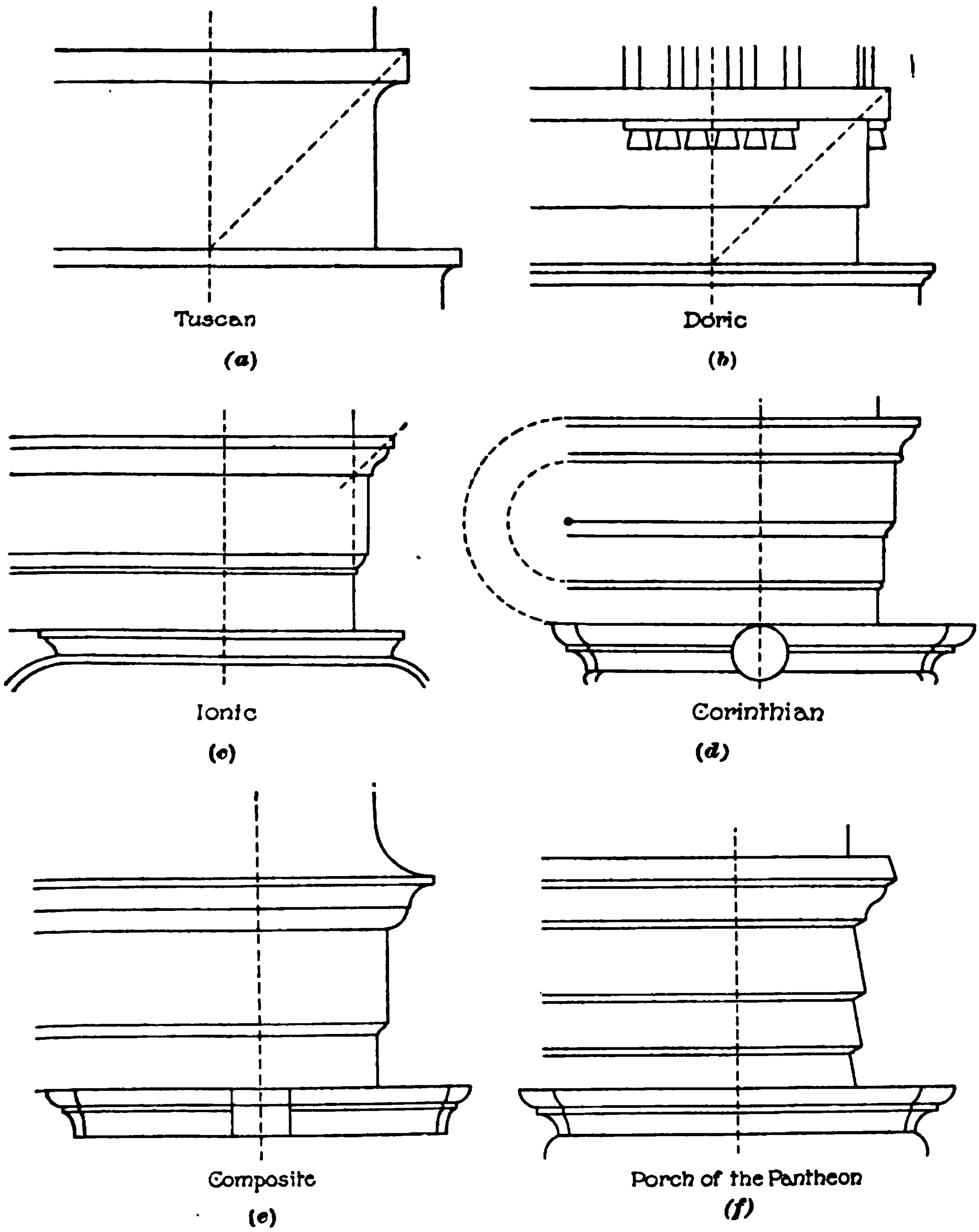

Tuscan
(a)
Doric
(b)
Ionic
(c)
Corinthian
(d)
Composite
(e)
Porch of the Pantheon
(f)

FIG. 48

90. The Doric capital, Fig. 49 (*b*), is also three-sixths of a diameter high, the two upper sixths being divided into thirds, and these again into thirds, to give the height of the smaller moldings. The denticulated capital generally has three fillets, the mutulary, and a bead and fillet.

The astragal, which in the other capitals is one-twelfth ot a diameter high, is in the Tuscan and Doric orders one-fourth smaller, or one-sixteenth of a diameter, the bead being one-twenty-fourth of a diameter high. In drawing the astragals, draw first the horizontal line at the top, which occupies two-thirds of the projection, otherwise the congé below is likely to be slighted. The bead and congé should have their full measure of 180° and 90°, as shown in Fig. 50.

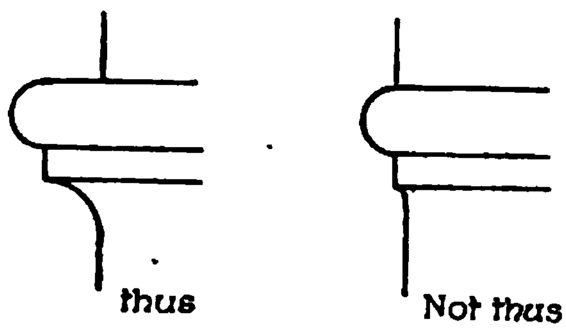


Fig. 50

91. The Ionic capital, which is one-third of a diameter in height, or four-twelfths, is also divided into three parts, but unequally. The abacus occupies the upper quarter, or one-twelfth, and had better be put in first. The echinus occupies rather more than half of the remaining space, namely, five-ninths. In the Composite capital, the abacus occupies the upper sixth and a little more, and the echinus and the astragal the next one, as shown in Fig. 35.

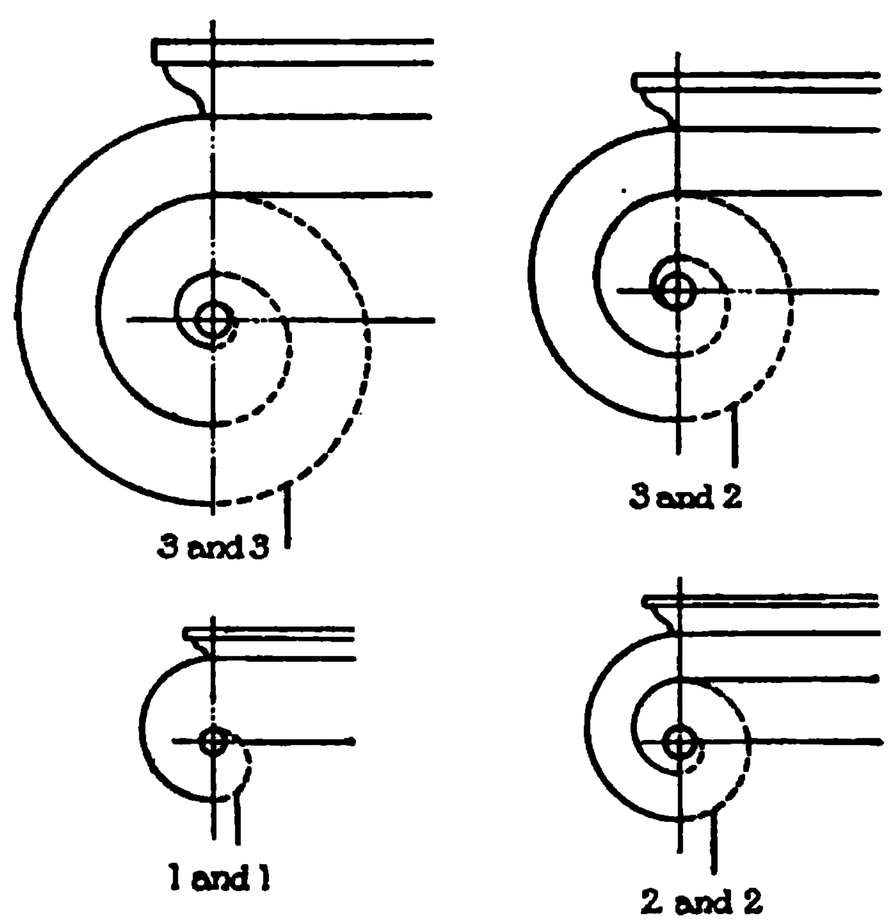


Fig. 51

The eyes of the Ionic scroll are in line with the top of the astragal and with the lower diameter of the column, and should be put in first, as in Fig. 51. The scrolls make three

complete turns and finally are tangent to the upper side of the eye. They can best be drawn by putting in first three semicircles on the outer side, and then three smaller ones on the inner side. In working on a small scale, two semicircles on each side will suffice, or three on the outer side and two on the inner, as in the plates. But one is never enough. The eyes of the Composite and of the Roman Ionic capitals are set nearer together, as shown in Fig. 35.

92. In drawing a Corinthian capital, Fig. 52 (*a*), it is best to put in first the astragal and the lower line of the architrave, carrying up on each side the outer lines of the shaft; then the abacus, fleuron, and scrolls. The double scroll at the

(*a*) (*b*)

FIG. 52

corner falls just outside of these vertical lines. It appears slightly elliptical in shape, not circular, and the outer scroll is more elliptical than the inner, being more foreshortened. The small scrolls under the fleuron are also foreshortened into ellipses; then the five leaves of the second row, the middle one in elevation, the two side ones in profile, and the other two at 45°, carrying down the mid-ribs to the astragal. Their tips turn down half a sixth, those of the corner leaves coming just on the outer lines of the upper shaft. Of the four leaves of the lower row, the two inner ones occupy the spaces between these mid-ribs, and the ends that turn over fall entirely within the outline of the lower parts. The two

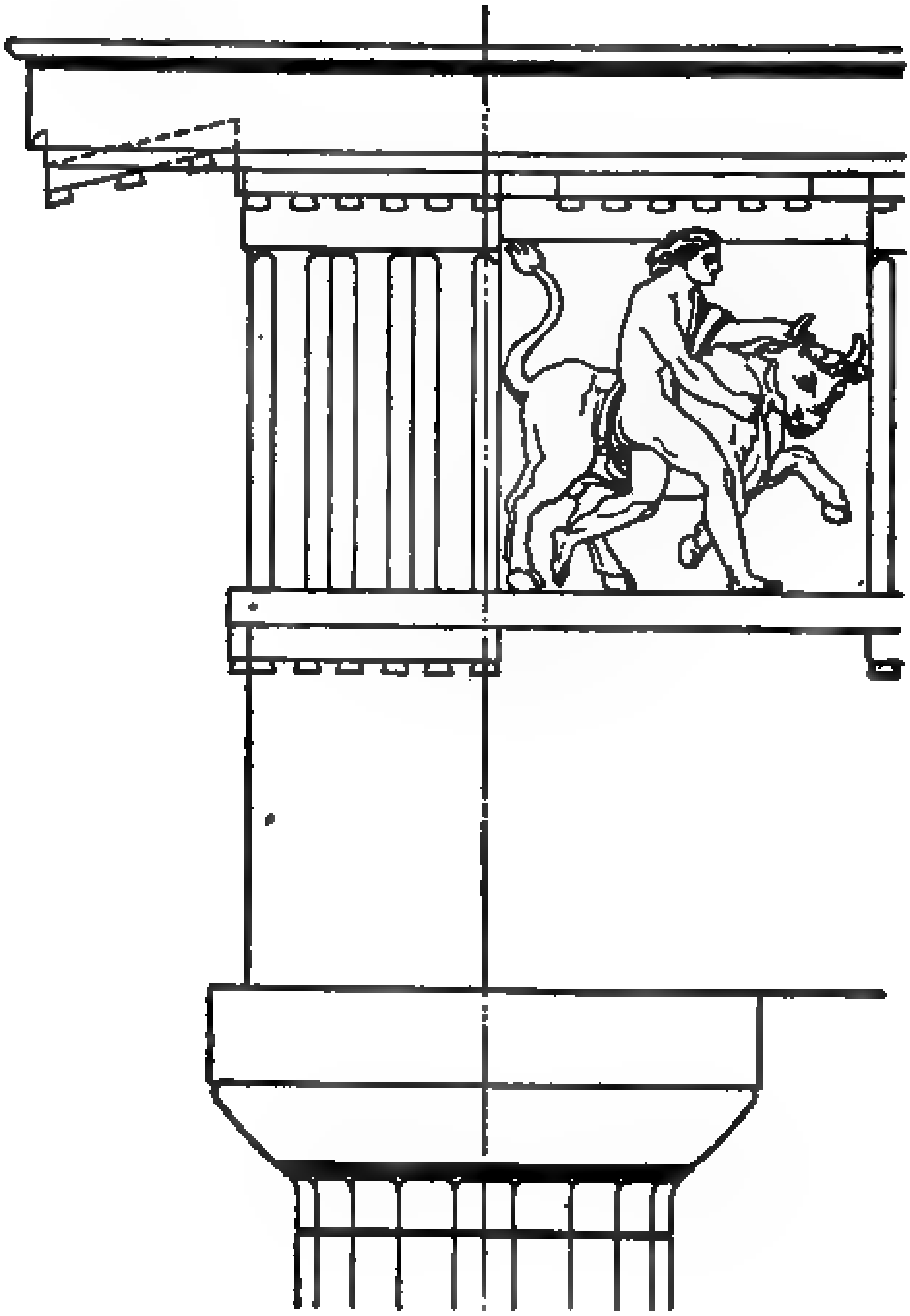
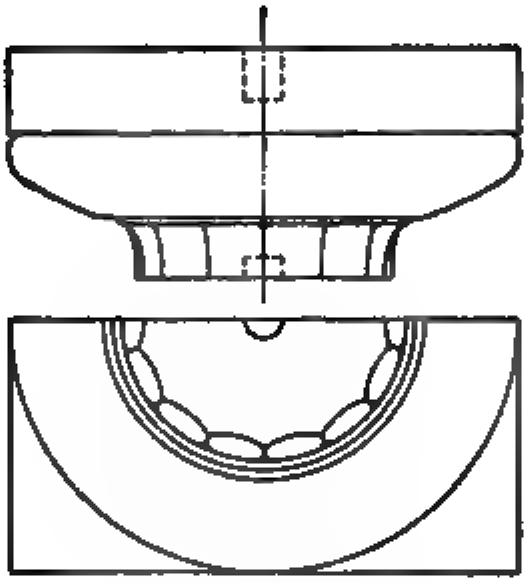
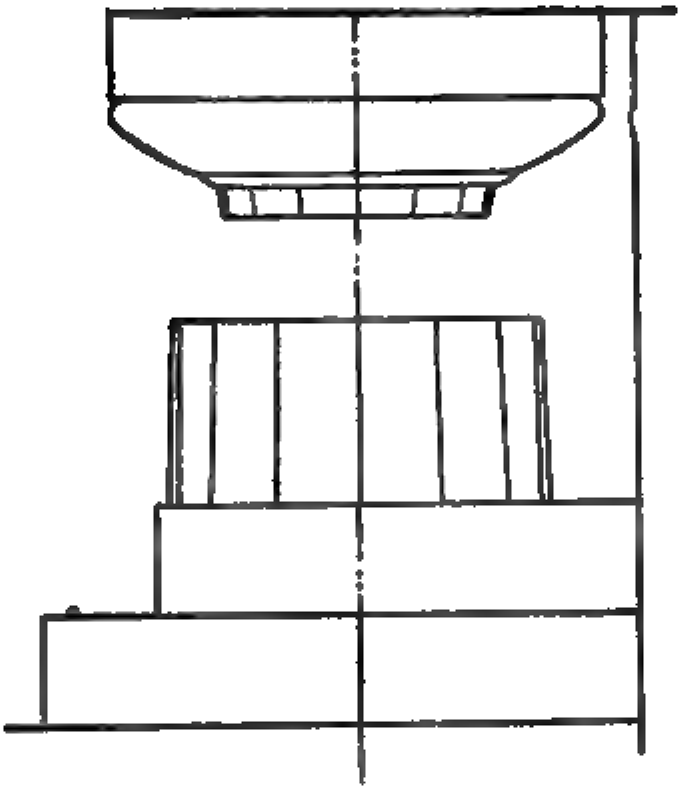


Fig. 53. M



14-Channels
Columns from Argos
(a)



Temple at Assos
(b)

(c)

Paestum Propylaea

(e)

(d)

Fig. 54

outer leaves extend on either side slightly beyond the width of the shaft below, and their tips fall just outside the lower lines of the leaves, being about six-sixths of a diameter apart. They accordingly come just over the outer lines of the lower diameter, just as the tips of the corner leaves above them come on the lines of the upper diameter.

A line drawn tangent to the astragal and to the abacus is also very nearly tangent in all three rows of leaves. The caulicoli, the buttons, the third row of leaves, and the lower parts of the volutes follow, in this order.

The smaller the scale of the drawing, the more straight and upright should the acanthus leaves be made, as shown in Fig. 52 (*b*).

THE GREEK ORDERS

93. Although the different examples of the Greek Doric and Ionic orders differ considerably among themselves, both in the proportions of the columns and in the treatment of details, the proportions of the entablature are tolerably uniform and are, in general, the same for both orders, the architrave and frieze being both about three-quarters of a diameter in height and the cornice about half a diameter, as shown in Fig. 53. The entablatures, as has been said, are about two diameters high, no matter how tall or how short the columns may be. Their chief characteristic is the height of the architrave and the shallowness of the cornice. The diminution and the entasis of the columns begin at the bottom of the shaft.

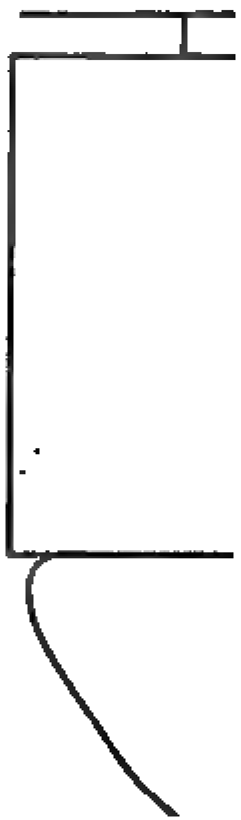
GREEK DORIC—PLATE XIII

94. The Greek Doric, Plate XIII, has no base, the shaft standing on three large steps, the upper one of which is called the *stylobate*, Fig. 53. It usually has twenty channels, which are generally elliptical in section, but some small columns have only sixteen, or even fourteen, as at Argos, Fig. 54 (*a*). In a number of examples, an arris instead of a channel comes on the axis of the column, as is seen both at Argos and at Assos, Fig. 54 (*b*). Instead of an astragal,

DORIC

FR

PART



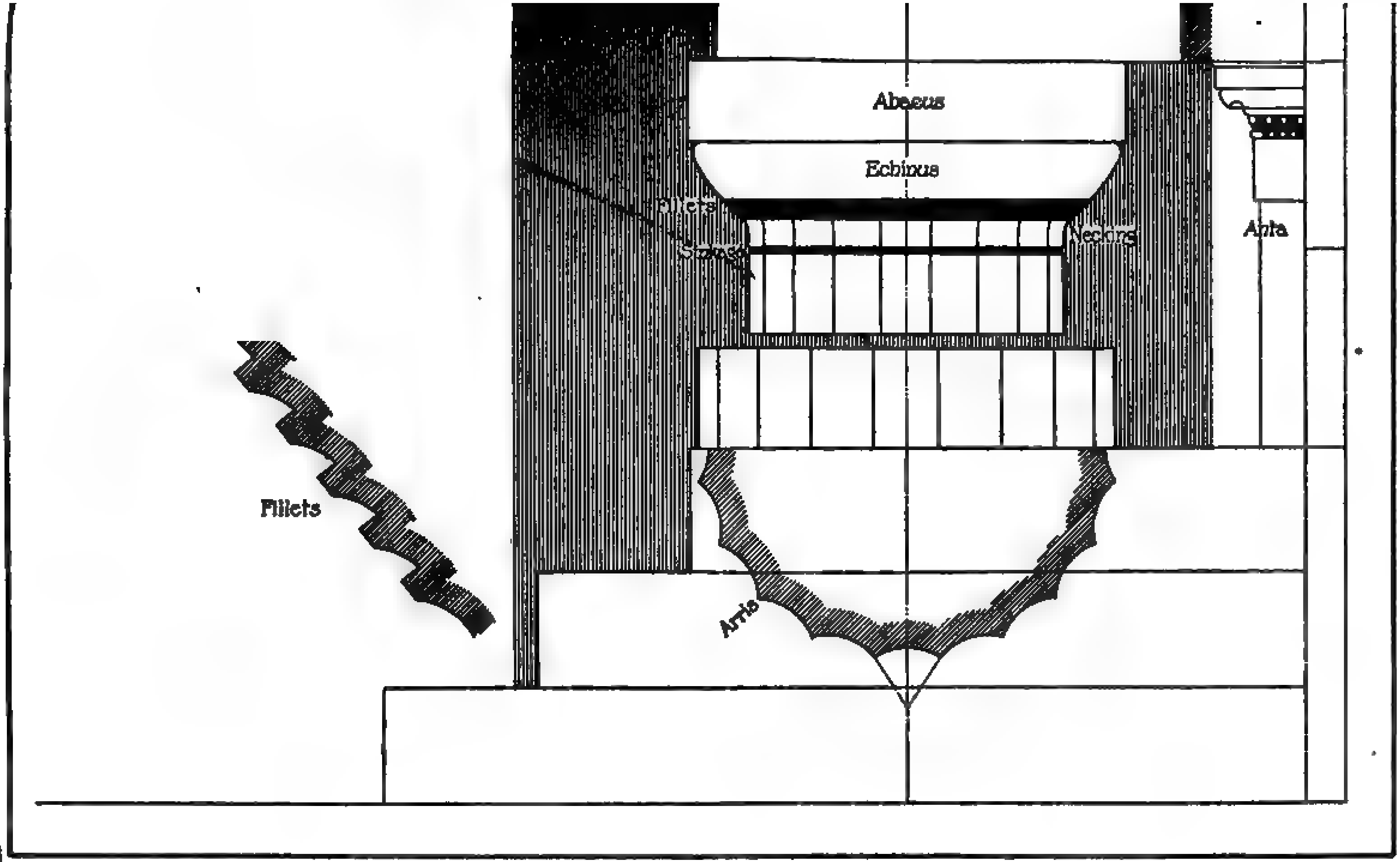


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PLATE XIII

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a groove, or *sinkage*, separates the shaft from the necking of the capital, and the channels are carried past it quite up to the fillets at the base of the echinus, as shown in Fig. 53. These fillets vary in number. They are not vertical on the face, but follow and continue the slope of the echinus, and their upper surfaces are also beveled, as in Fig. 54 (*c*). The echinus itself has an elliptical or hyperbolic profile, the earlier examples being the most convex and the later ones hardly differing from a straight line. The abacus has no moldings.

95. The architrave also is plain, and is crowned by a tænia, below which is a broad regula and six short guttæ. In the earlier examples, the face of the architrave is set just over and in line with the upper diameter of the shaft, but in the later ones, it overhangs, coming over the lower diameter, and the echinus is made steeper, as well as straighter, as has been said, as if to support it.

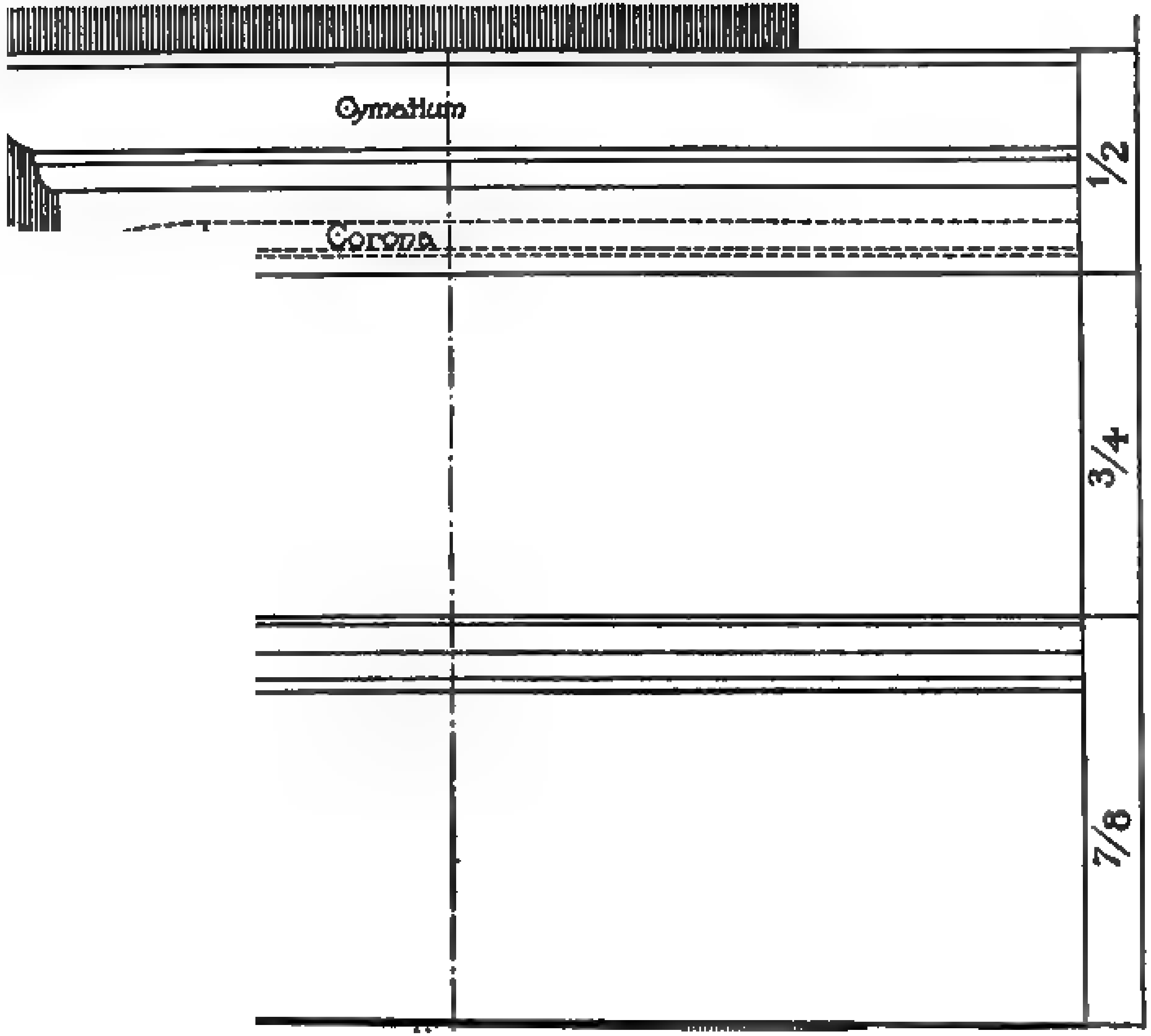
The triglyphs in the frieze are shorter and broader than in the Roman Doric, and are set flush with the architrave below, the metopes being set back. They are also thicker than the Roman triglyphs, and the channels are deeper, those at the edges cutting back at an angle of 45°, the others generally at 60°, and they run nearly up to the broad fillet, or band, that constitutes the cap of the triglyph. This is only as wide as the triglyph itself, not breaking round the corners, and it is not continued between the triglyphs, the cap of the metopes being narrower.

As in Vignola's denticulated Doric, the mutules on the soffit of the corona slope up, and have only eighteen guttæ, and they occur over the metopes as well as over the triglyphs, as shown in Fig. 54 (*d*). The mutules are thicker than those in the denticulated Doric, though not so thick as in the mutulary. The cymatium generally consists of an elliptical ovolo and a fillet, the soffit of which is beveled. But different examples vary in almost every one of these particulars.

At the corner of a building the triglyphs are set, not over the axis of the column, but at the extreme end of the frieze, two coming together and making a solid block. As the

FIG 85

IONIC ORDER
FROM THE TEMPLE
ON THE ILLISSUS



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metopes do not vary in size, being nearly square, this brings the three corner columns nearer together than the others.

96. In the best Greek examples, all the columns slope in a little, so that the corner column, which is a little bigger than the others, has its inner face nearly vertical. The horizontal lines curve slightly, being convex up, the vertical faces incline a little, either out or in, and the moldings are, as has been stated, generally elliptical or hyperbolic in section, rather than arcs of circles.

The columns vary in height from about five to eight diameters, the earlier ones being the shortest. The entasis, or curvature in the outline of the shaft, and the diminution in the width of the shaft, from bottom to top, which sometimes amounts to one-third of the diameter, are also much more pronounced in the earlier examples than in the later ones, as shown in Fig. 54 (*e*). This seems to show that the original of the Doric column was not a wooden post, as has been thought, nor a pile of masonry, but probably a piece of rubblework covered with stucco, like the rubble walls.

GREEK IONIC–PLATE XIV

97. The general proportions of the Greek Ionic entablature, Plate XIV, are, as has been stated, about the same as in the Doric, but the columns are more slender, varying from about seven diameters in height to more than ten, and the architrave, frieze, and cornice are often made very nearly equal in height, as shown in Fig. 55.

The base is like the Attic base, except that the scotia is larger, constituting the principal feature, that the upper torus is larger than the lower one, that the fillet above the scotia projects as far as the face of this torus, and that there is no plinth. As the base is still half a diameter high, the upper torus and scotia are very much larger than in the Roman Attic base. The lower torus is sometimes very small indeed, and is occasionally omitted altogether, as in one of the Choragic columns on the south side of the Acropolis at Athens, Fig. 30 (*f*).

(a)

(c)

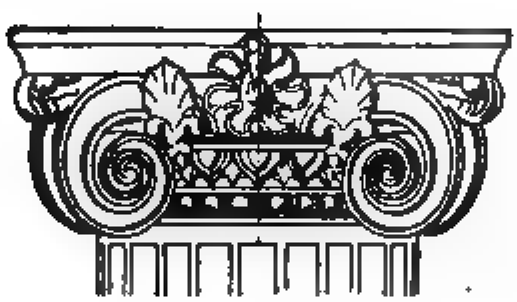
(b)

Fig. 56

98. The shaft is fluted just as in the Roman Ionic, having twenty-four channels, and the capital resembles, in general, Vignola's capital with balusters. But the scrolls are much larger, measuring a full diameter and a half from side to side, and two-thirds of a diameter from the architrave to the bottom of the curve. The capital, measured from the

(b)

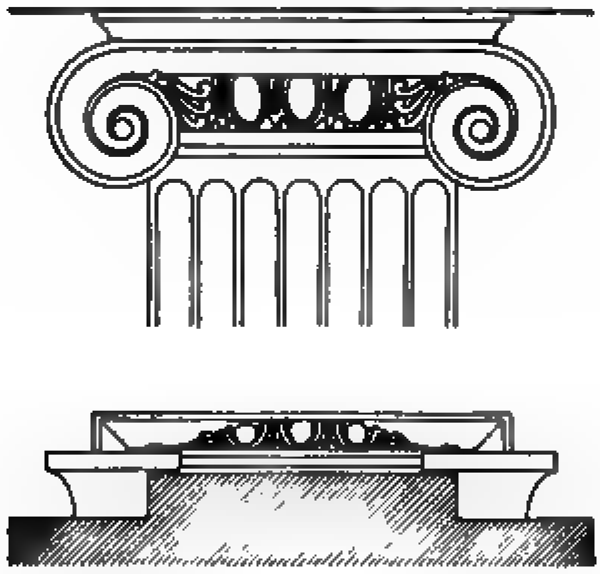
(a)



(c) (d)

Fig. 57

architrave down to the astragal, is half a diameter high, instead of a third; the abacus is very small, consisting generally of a single ovolo; and the *cushion* between the abacus and the echinus is very wide, its lower outline being curved downwards, as shown in Fig. 56 (*a*). The sprigs of honeysuckle, accordingly, do not cover the eggs and darts, five of which are visible between the scrolls, instead of three.

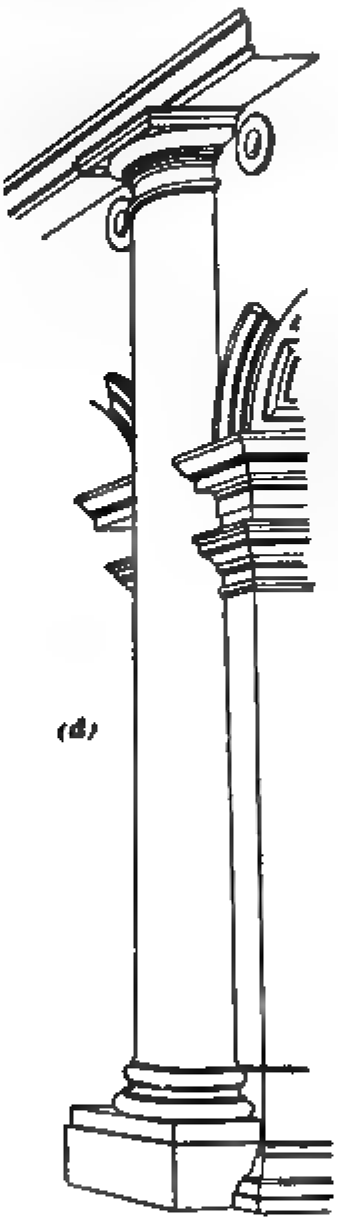


(a)

(b)

Column

(c)



(d)

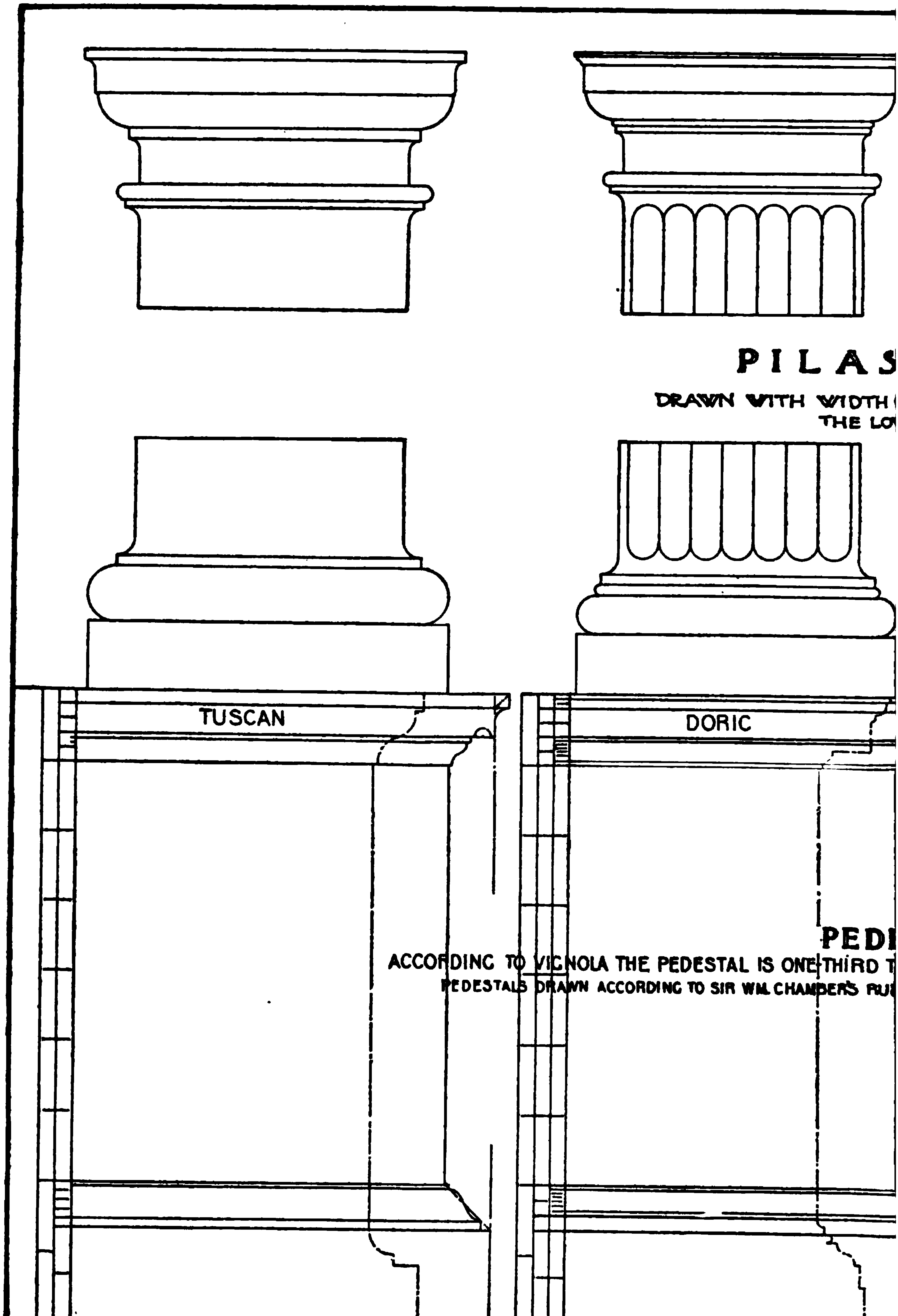
From the Farnese Palace

Pilaster

(e)

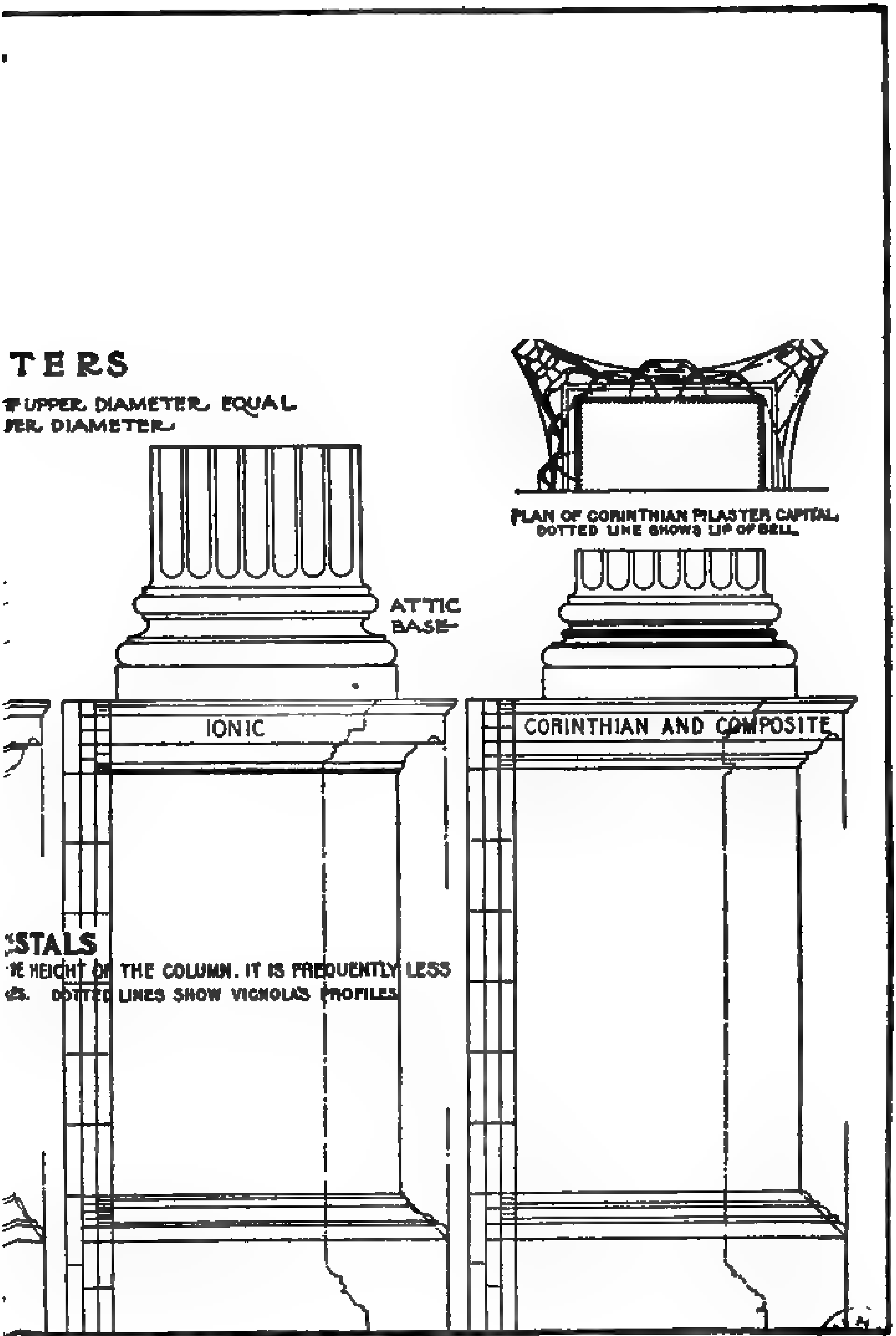
Fig. 58

PEDESTALS AN



PLAT

D PILASTERS



ATE XV

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99. The architrave is sometimes plain, and sometimes divided into two or three bands. The frieze, or zoöphorus, is wide, and the bed mold that crowns it is often countersunk into the soffit of the corona, so that it does not show in elevation, as in Fig. 55. It is noticeable that though dentils are, historically, a distinctively Ionic feature, they are omitted in many Greek examples. The cymatium is a large cyma recta, and has a fillet and bead below it, which is sometimes undercut, so as to make a little beak molding.

But here, as in the Greek Doric, there is a great variety in the details of different buildings. The four faces of the capital are sometimes made alike, with double scrolls on each corner, as in the Roman Ionic, and these scrolls are sometimes connected under the abacus by a continuous curve, convex up, instead of by a horizontal line, as shown in Fig. 56 (*d*). Sometimes a corner column shows scrolls on the two outer faces and balusters on the two inner ones, the double scroll on the corner projecting at 45°, as in Fig. 56 (*b*). Some examples have a wide necking, adorned with the honeysuckle ornament, below the echinus, as shown in Fig. 56 (*c*).

100. A few Corinthian capitals are to be found in Greece, but the buildings in which they occur are in other respects Ionic, or even Doric [see Fig. 57 (*a*)].

In the later Greek colonies in Southern Italy are found interesting varieties of all the orders.

The Corinthian capitals receive a local development quite unlike that which was finally adopted in Rome itself, as at Tivoli, Fig. 57 (*b*) and (*c*), Pompeii, and Herculaneum Fig. 57 (*d*). Since the revival of Greek architecture, other variations have appeared in France, Germany, and Italy.

PILASTERS—PLATE XV

101. The Romans made their pilaster capitals resemble those of the columns. This works well, except with the Ionic capital, in which the projecting echinus presents an almost insuperable difficulty, as is evident in Fig. 58 (*a*).

As **pilasters** do not generally diminish in width at the top, their capitals are one-fifth broader than those of the columns. But pilasters are often made half a sixth narrower than the columns at the bottom, and half a sixth wider at the top, having thus a uniform diameter of five-sixths and a half. In the Corinthian pilaster capital, the extra space is taken up by making the leaves a little broader, and setting them farther apart, as shown in Fig. 58 (*b*).

Pilasters generally project from the wall a quarter of their diameter, but sometimes they have to be made thicker in order to receive string-courses or other horizontal moldings that they cut across. If made much thicker than this, they are likely to look thicker than the columns alongside of them, and piers always do, noticeably enhancing the slenderness of the columns near them.

The Greeks gave their pilasters bases like those of the columns, but capitals of their own, composed of a series of moldings, as shown in Fig. 58 (*e*), which is a Greek pilaster capital differing from the column capital in (*d*), but similar in some details.

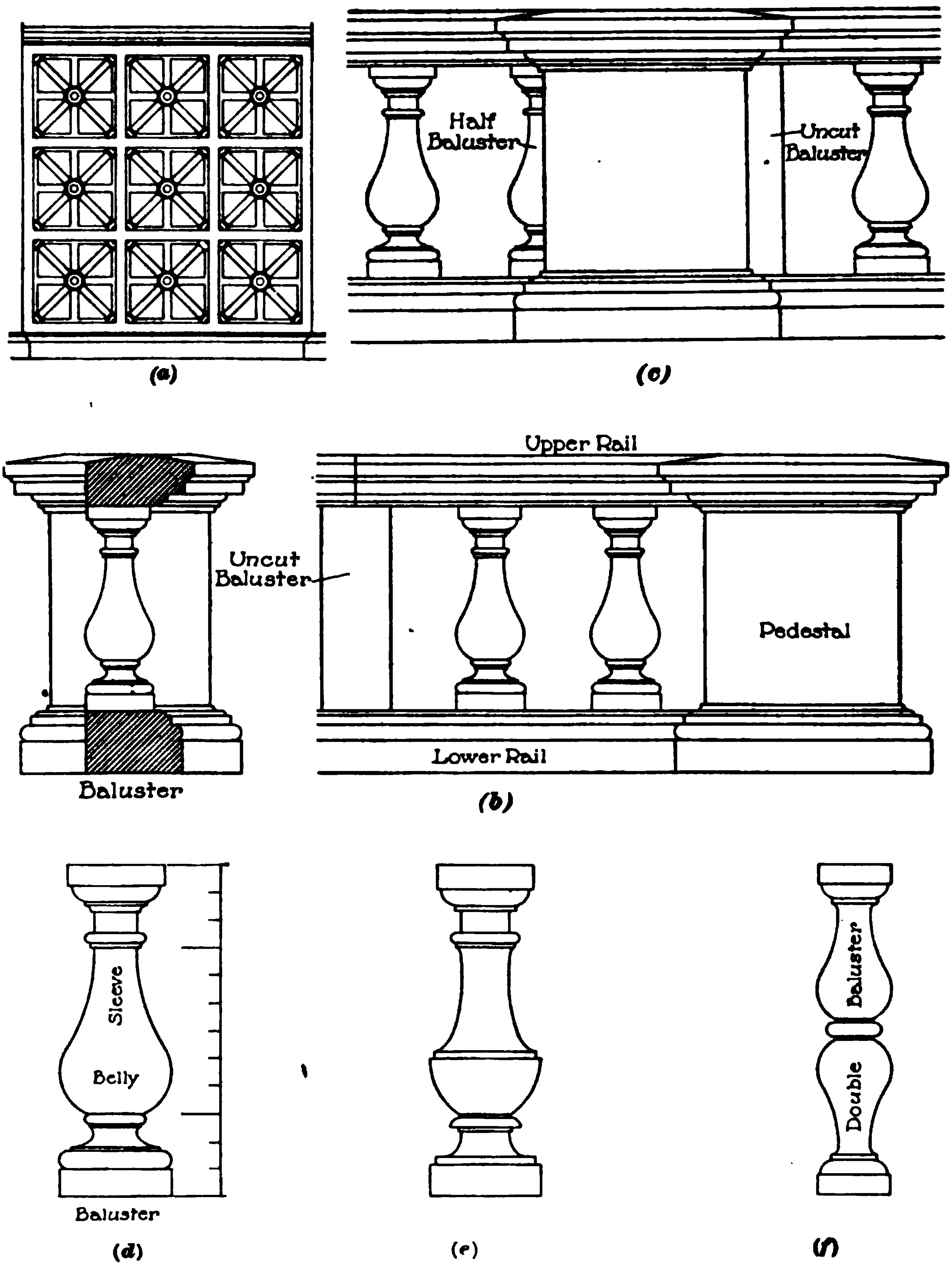
Pilasters are preferable to half columns, which always look smaller than they are, and have a weak appearance. Moreover, any moldings that they interrupt seem to cut them in two, as shown in Fig. 58 (*d*). In these respects, three-quarter columns are better, though they are likely to look clumsy, and they inevitably make an awkward junction with the wall behind them. They also make it uncertain which is the principal supporting member, the wall or the column.

PEDESTALS, ETC.—PLATE XV

102. As has already been said, a short pier is called a post, and, if it supports something, a **pedestal**. The pedestals that support columns are generally made one-third the height of the column. The cap is one-ninth the height of the pedestal, and generally consists of a bed mold and corona. There is no cymatium, a gutter being obviously out of place, but the corona is crowned by a fillet and small

(b)

FIG. 59



(a)
Half Baluster
Uncut Baluster
(c)
Upper Rail
Uncut Baluster
Pedestal
Lower Rail
Baluster
(b)
Sleeve
Belly
Baluster
(d)
(e)
Double
Baluster
(f)

FIG. 60

cyma reversa. The base, which is two-ninths of the height of the pedestal, or, according to Vignola, only one-ninth, like the cap, consists of a plinth and several combination base moldings, among which a cyma recta with a torus below it is generally conspicuous.

103. The moldings, in both cap and base, are fewer and consequently larger and simpler in the Tuscan and Doric orders than in the Ionic and Corinthian, the Tuscan, according to Vignola, having no corona, and the Corinthian a necking and astragal. The cap projects less than its own height, in many examples, and the plinth just as much as the corona.

But pedestals vary greatly both in their proportions and in their moldings.

104. Parapets.—A wall low enough to lean on is called a **parapet,** and whether low or high is often strengthened by occasional posts or pedestals, sometimes of the same height, sometimes higher. In either case, the wall, or parapet, has a cap and base, which may or may not be like those of the pedestals or posts. A similar strip of wall, with the wall continued above the cap, as shown in Fig. 59, is called a *continuous pedestal.* This often occurs between the pedestals that support pilasters.

105. Balustrades.—In antiquity, parapets were often pierced by triangular penetrations, apparently in imitation of wooden fences, as shown in Fig. 60 (*a*). But in modern times the openings in parapets are generally filled with a sort of colonnade of dwarfed columns called **balusters.** These frequently occupy the whole space between one post or pedestal and the next, forming a **balustrade,** as shown in Fig. 60 (*b*). If the distance is great so that the cap has to be made of several lengths of stone, a block called an *uncut baluster* is placed under the joint. Not more than a dozen balusters should occur together without such interruption. Against the pedestal is often set a half baluster, or, which is better, half of an uncut baluster, to support the end of the upper rail, as in Fig. 60 (*b*).

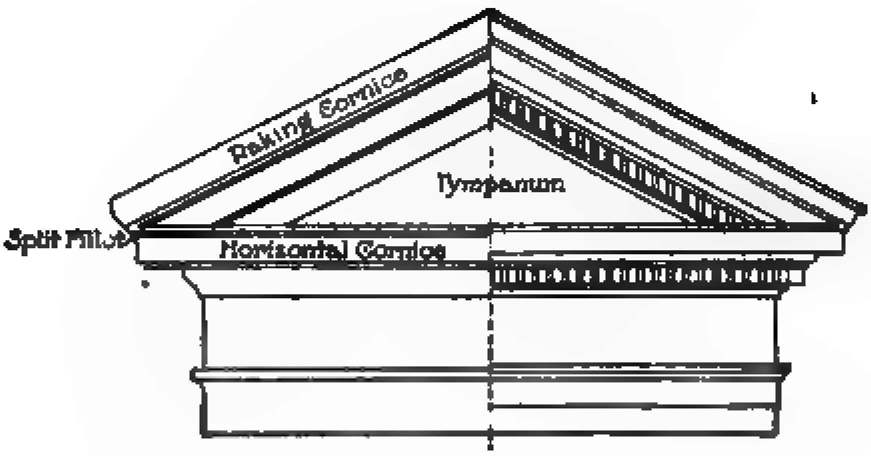
106. The cap and base of the pedestals, or of the parapet or continuous pedestal, are called in a balustrade the *upper* and *lower rails*. The baluster supports the upper rail as a column supports an entablature, and stands on the lower rail as on a stylobate, as in Fig. 60 (*c*). It has its own cap, the height of which, including the astragal, is one-quarter the height of the baluster, and which consists of a plain abacus, echinus, and fillet and necking. These three members are of equal height, as in the Tuscan and Doric capitals.

The base of the baluster is also one-quarter its total height and resembles the Attic base. The scotia, as in the Greek Attic base, is generally made the principal member.

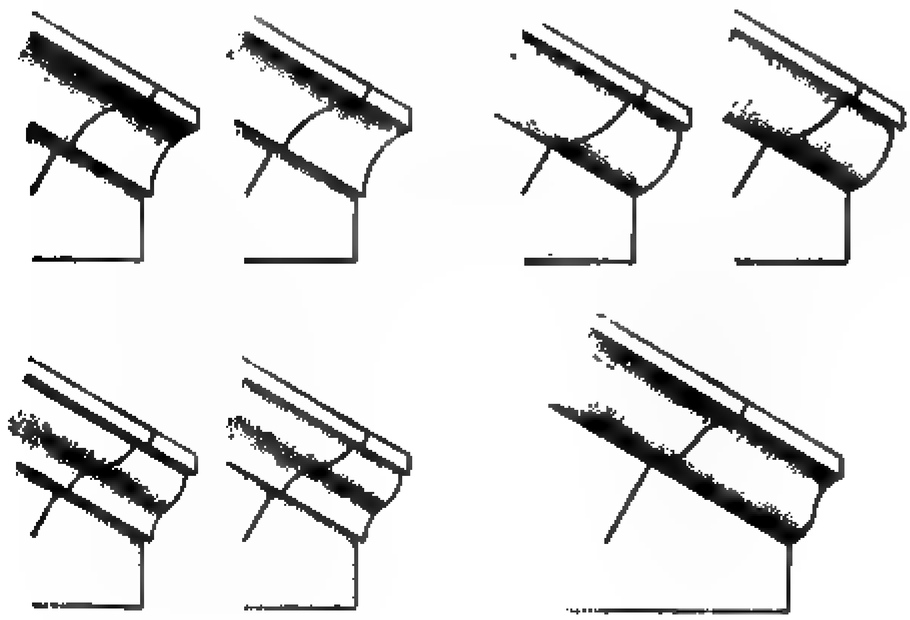
Between the cap and the base is the shaft, or *sleeve*, which has the outline of a quirked cyma reversa, the greatest diameter, or *belly*, coming at about one-fourth of its height, or one-third the height of the baluster, as in Fig. 60 (*d*). Its width at this point is also one-third the height of the baluster, as is also that of the plinth of the base, exactly, and the width of the abacus, almost. The necking is less than half as wide. The point of contrary flexure in the cyma reversa is half way between the cap and the base, or between the upper and lower rails. But these proportions are made somewhat lighter for use with the Ionic and Corinthian orders.

The rails vary in height, being usually from one-sixth to two-sixths of the space between them, like the cap and base of a continuous pedestal; but they are often made much heavier, even one-third or one-half, according to the position of the balustrade.

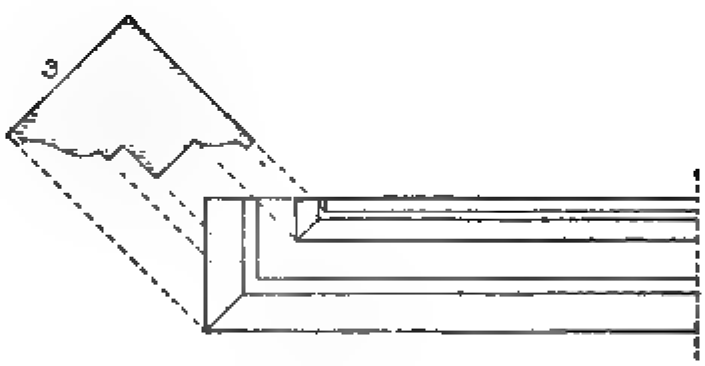
107. Instead of the cyma reversa, a beak molding, as in Fig. 60 (*e*), is often used, and other variations are frequent. Of these, the most important is the so-called *double baluster*, which consists of two small balusters, set together base to base, as in Fig. 60 (*f*). Vignola also used a high block under the plinth. Balusters are often made square in section, like piers, instead of round, like columns. Balusters are set about half their height apart, on centers.



(a)



(b)



(c)

FIG. 61

A balustrade, like a parapet, is intended to lean on, and should not be more than about 3 or 4 feet high. While, therefore, columns and entablatures are proportioned to the size of the buildings in which they occur, varying in height from 10 or 12 feet to 50 or 60, balustrades, like steps, are proportioned to the size of the human figure, and in large buildings are relatively much smaller than in small ones. They thus serve, as do steps, and as does the human figure when introduced into a drawing, to indicate the scale of a building.

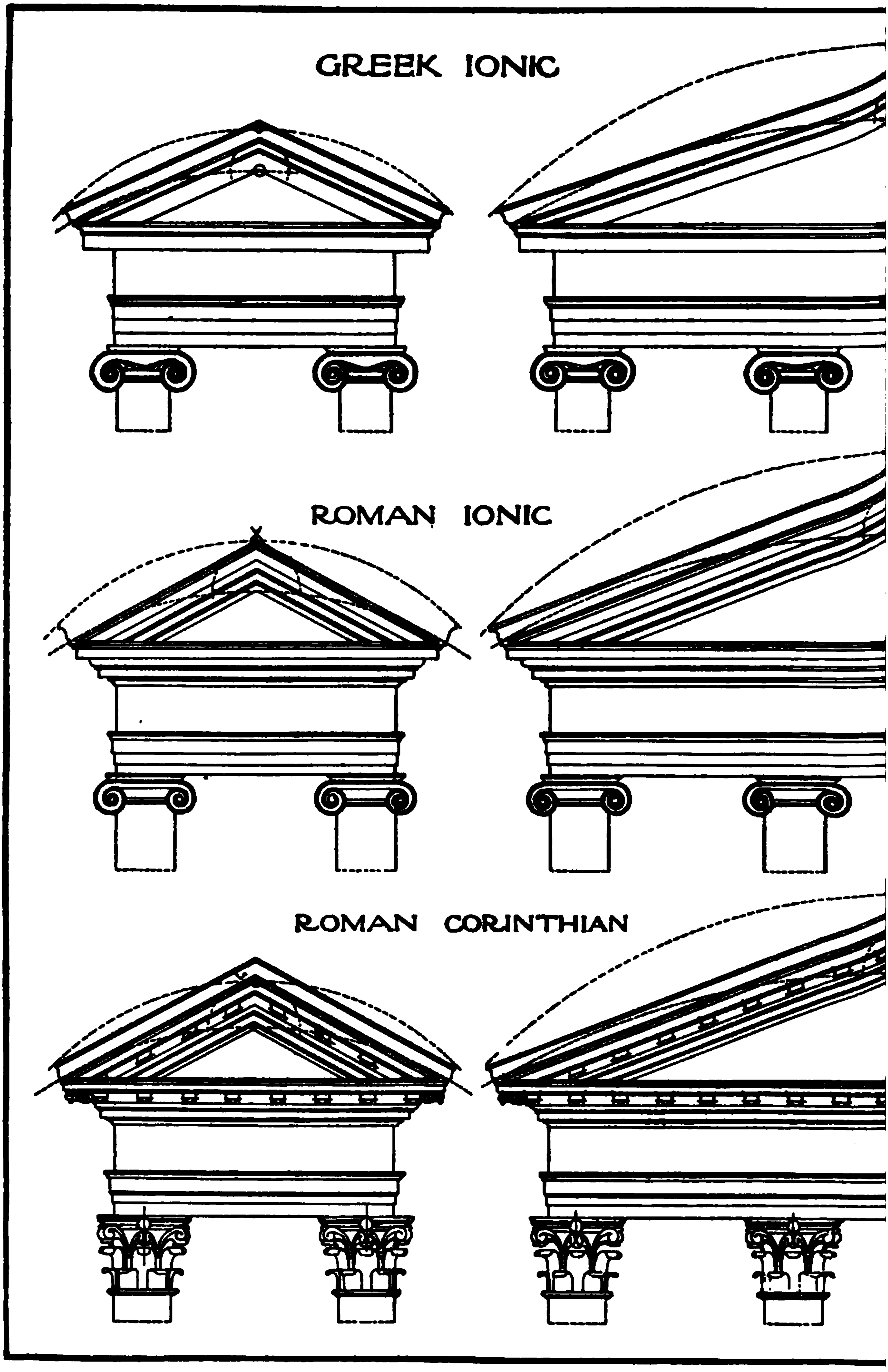
But in very large buildings balustrades have sometimes been made of colossal dimensions, that on the top of the front of St. Peter's, for example, being about 8 feet high.

108. Attics.—When a parapet is placed on top of an entablature it is called an **attic**, Fig. 59 (*a*). Like pedestals, attics vary much in size and in architectural treatment. They are generally made about a quarter as high as the order below, and should not be more than a third. They should have a high plinth, or even a double plinth, as in Fig. 59 (*b*), so as not to be too much hidden by the projection of the cornices on which they stand.

As shown in Fig. 59 (*c*), the place of an attic is often taken by balustrades, which also should have high plinths below the lower rail.

PEDIMENTS—PLATE XVI

109. The gable on a classical building, as in Fig. 61 (*a*), is called a **pediment**. It consists of a triangular piece of wall, called the *tympanum*, which is in the same plane as the frieze below; a *horizontal cornice*, which divides the tympanum from the frieze; and two pieces of inclined cornice that surmount the tympanum. The inclined, or *raking*, *cornice* is like the cornice that crowns the wall on the sides of the building, but the cymatium is a little wider. The horizontal cornice has no cymatium, and generally terminates in a fillet, called the *split fillet*, which divides at the angle where the two cornices come together.



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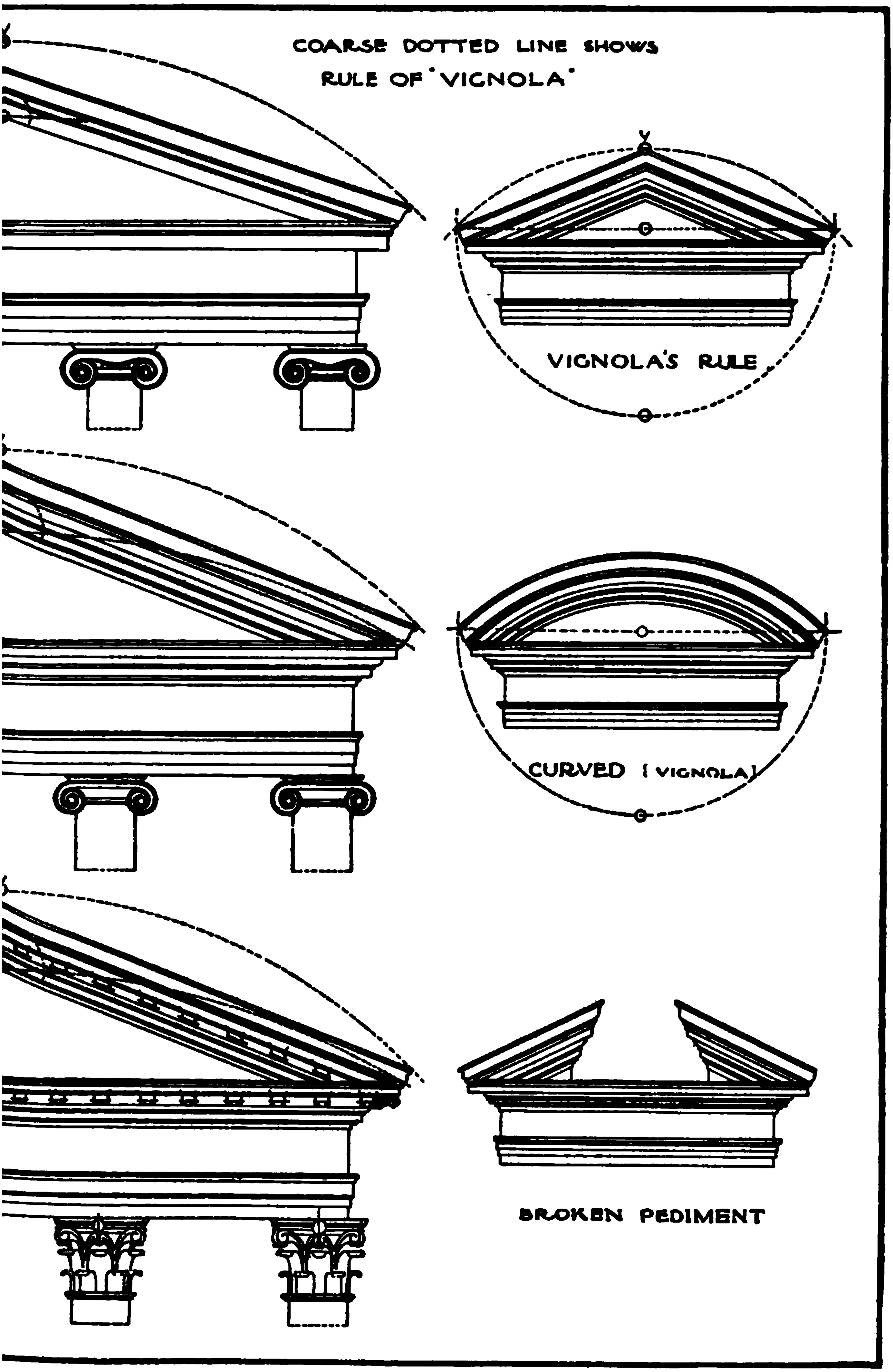

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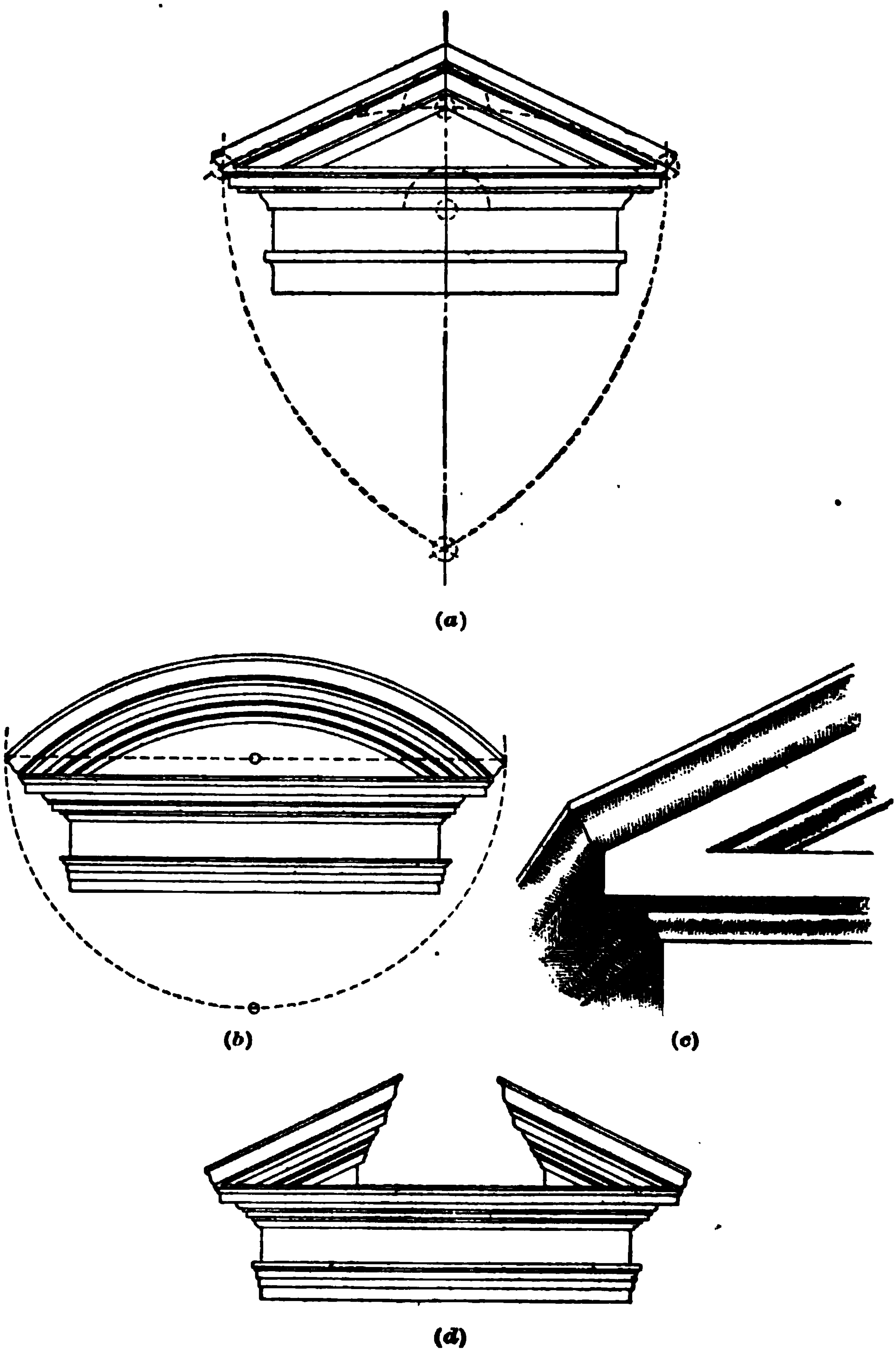
If the cymatium is a cavetto, the under side of the fillet beneath it is beveled, either on the rake or along the wall; if it is an ovolo, the same thing happens to the fillet above it, as in Fig. 61 (*b*). With the cyma reversa, both occur; with the cyma recta, neither, the fillets having no soffit. This is one of the reasons for employing this molding in this place.

When a cyma recta is used in the cymatium, it occurs in four different forms, as shown in Fig. 61 (*c*), namely, (1) the profile of the molding along the wall; (2) the profile of the raking molding; (3) the line of intersection of these two moldings, which lies in a vertical plane, set at 45°; and (4) the line of intersection of the two raking moldings at the top. The forms (1), (2), and (4) have the same projection but different heights, while forms (1) and (3) have the same height but different projections.

110. According to Vignola, the obtuse angle at the top of the pediment is included within an arc of 90°; it accordingly gives a slope of 22½°. This is a good rule for most cases, but if a building is high and narrow, the slope needs to be steeper; if it is low and wide, the slope must be flatter. Inasmuch, however, as, for a building of a given width, the higher it is, the larger is the scale of the order employed and of all the details of the order, it follows that, for a given width of front, the larger the moldings are, the steeper must be the slope.

On this is founded the following rule for the slope of pediments, devised by Stanislas L'Eveillé: Taking the upper line of the horizontal cornice, Fig. 62 (*a*), as one side, construct below it an equilateral triangle; and taking the vertex of this triangle as a center, and its sides as a radius, describe an arc of 60°. Taking, then, the summit of this arc as a center, describe a circle, the radius of which is equal to the width of the horizontal cornice. Lines drawn from the extremities of the corona tangent to this circle will give the upper line of the raking corona.

It is obvious that the larger the cornice, relative to the length of the front, the steeper will be the slope. It is also



(a)

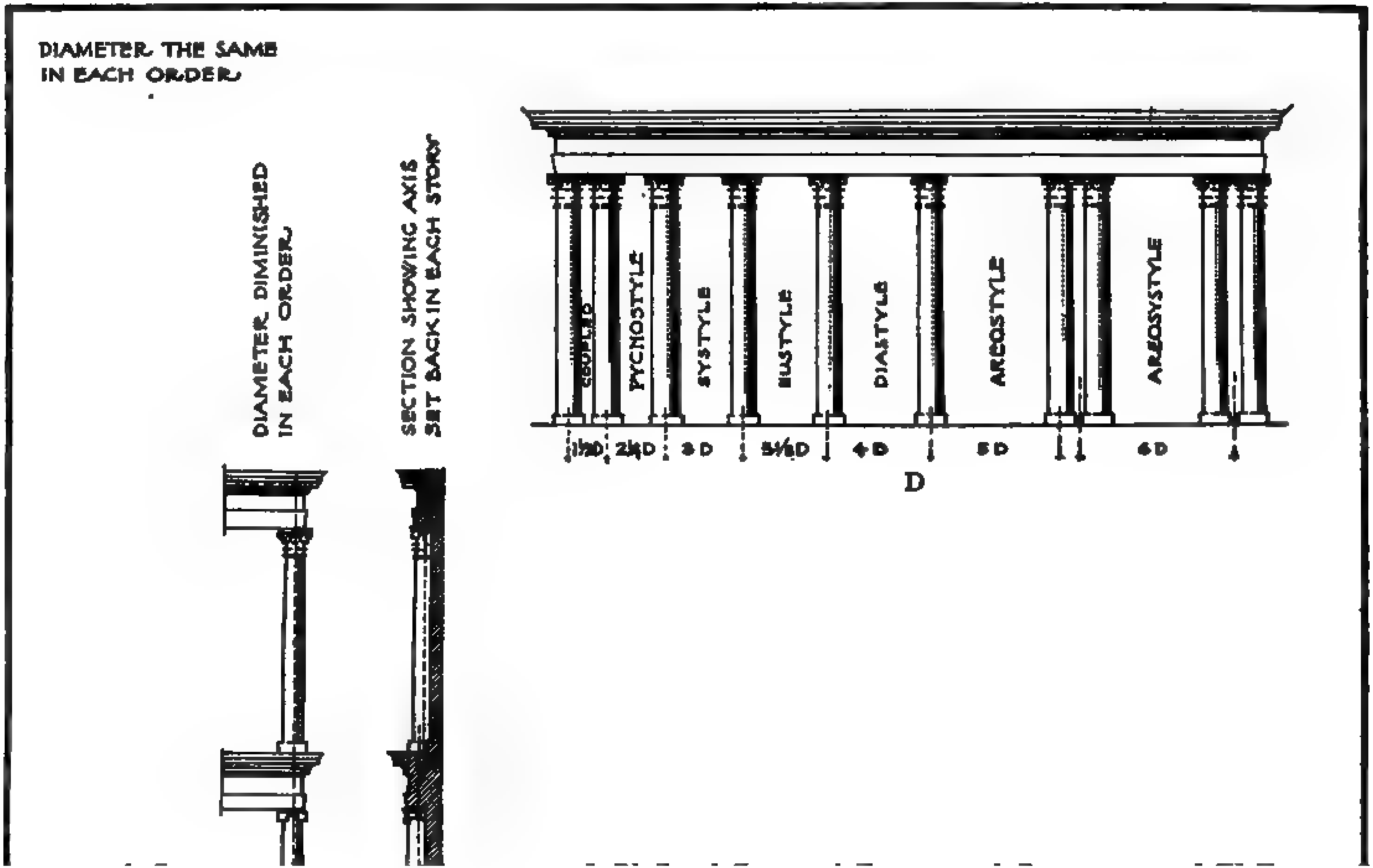
(b)

(c)

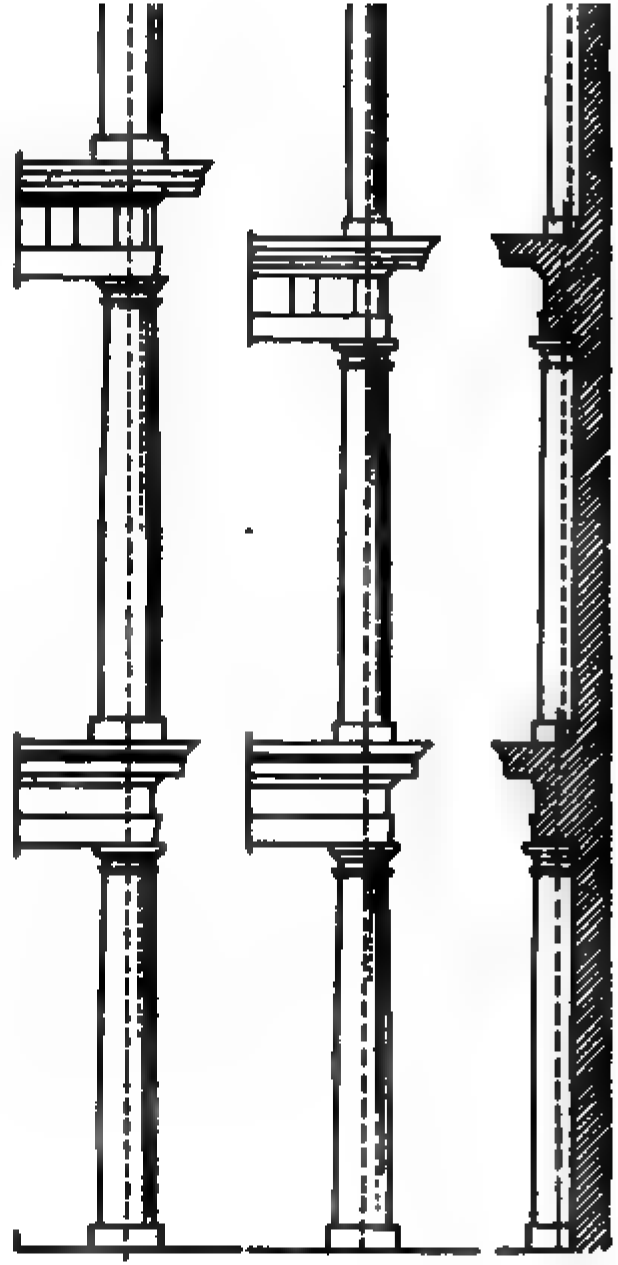
(d)

FIG. 62

SUPERPOSITION AND INTERCOLUMNIATION



E



A B C

/STYLE

ONO-TRIGLYPHIC

F

PLATE XVII

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plain that this rule gives steeper pediments for the Corinthian and Ionic orders than for the Doric and Tuscan, and for the Roman orders than for the Greek, the cornices being wider.

Circular, or *curved, pediments* have a sweep of 90°, as in Fig. 62 (*b*), starting at an angle of 45°.

When pediments are used merely for ornament, the upper part is sometimes omitted, giving a *broken pediment*, as shown in Fig. 62 (*d*).

If the molding that crowns the corona is omitted, the faces of the three coronas are continuous, as shown in Fig. 62 (*c*).

INTERCOLUMNIATION—PLATE XVII

111. The space between the two columns, measured just above their bases, is called an **intercolumniation.** It is one diameter less than their distance apart on centers, or on edges.

Columns are said to be *coupled*, or to have a *pycnostyle, systyle, diastyle*, or *areostyle intercolumniation*, according as they are set close together, or are one, two, three, or four diameters apart; as nearly as may be; that is, about one, two, three, four, or five diameters on centers. The systyle and diastyle are the most usual, with an intercolumniation of two or three diameters. But coupled columns cannot be nearer than one and one-third diameters, on centers, instead of one diameter, on account of the projection of their bases, and in the Ionic, Corinthian, and Composite orders, not nearer than one and one-half diameters, on account of the projection of their capitals. The intercolumniation of coupled columns is accordingly made one-third or one-half of a diameter, or even a little more, so as to prevent the bases or caps from actually touching.

So also the pycnostyle intercolumniation is made one and one-fourth diameters instead of one diameter (that is, two and one-fourth diameters on centers, instead of two), to avoid crowding. The ancients thought that even the systyle columns, with an intercolumniation of two diameters, came

too near together, and preferred what they called the ***eustyle intercolumniation***, of two and one-half diameters (or three and one-half diameters on centers in place of three diameters). But the moderns prefer to make the eustyle intercolumniation two and one-third diameters (setting the columns three and one-third diameters on centers), as this brings every

Fig. 68

column in Ionic and Corinthian colonnades exactly under a dentil, and every alternate one just under a modillion, the dentils being one-sixth of a diameter on centers and the modillions two-thirds of a diameter.

112. The wider intercolumniations are preferable, obviously, when the columns are small, since otherwise it might

be difficult to get between them; and the systyle, or even the pycnostyle, when the columns are very large, since otherwise it might be difficult to find stone architraves long enough to span the interval. But the ancients used Tuscan columns chiefly with wooden architraves, setting them as much as seven diameters apart, which is called *Tuscan intercolumniation*, and which makes the space between the columns about square. In modern times, also, an arrangement of coupled columns, called *areosystyle*, has been employed, the columns being set half a diameter apart and the space between the pairs of columns made three and one-half diameters. This is greater than the diastyle intercolumniation and less than the areostyle by half a diameter. From the axis of one pair of columns to that of the next pair, the distance is six diameters. If, in a systyle colonnade with the columns three diameters on centers, the alternate columns are moved along until they nearly touch the intervening ones, the result is an areostyle colonnade. This was first used by Perrault in the eastern colonnade of the Louvre, as shown in Fig. 63.

In actual practice these rules for intercolumniation are seldom exactly followed, as circumstances vary their application.

113. Doric Intercolumniations.—In the Doric order, since the columns come exactly under the triglyphs, and the triglyphs are one and one-fourth diameters on centers, as on edges (the width of the triglyph being one-half of a diameter and that of the metopes three-fourths of a diameter), the distance of the columns on centers must be a multiple of one and one-fourth diameters.

This makes the coupling of Doric columns difficult, since, even if the bases touch, the distance between axes is still one and one-third diameters, which is more than that of the triglyphs by one-twelfth of a diameter. This slight discrepancy can, however, be got over by making each base a trifle narrower, or the triglyphs and metopes a trifle wider, or by putting the columns not exactly under the triglyphs, or by employing all these devices at once.

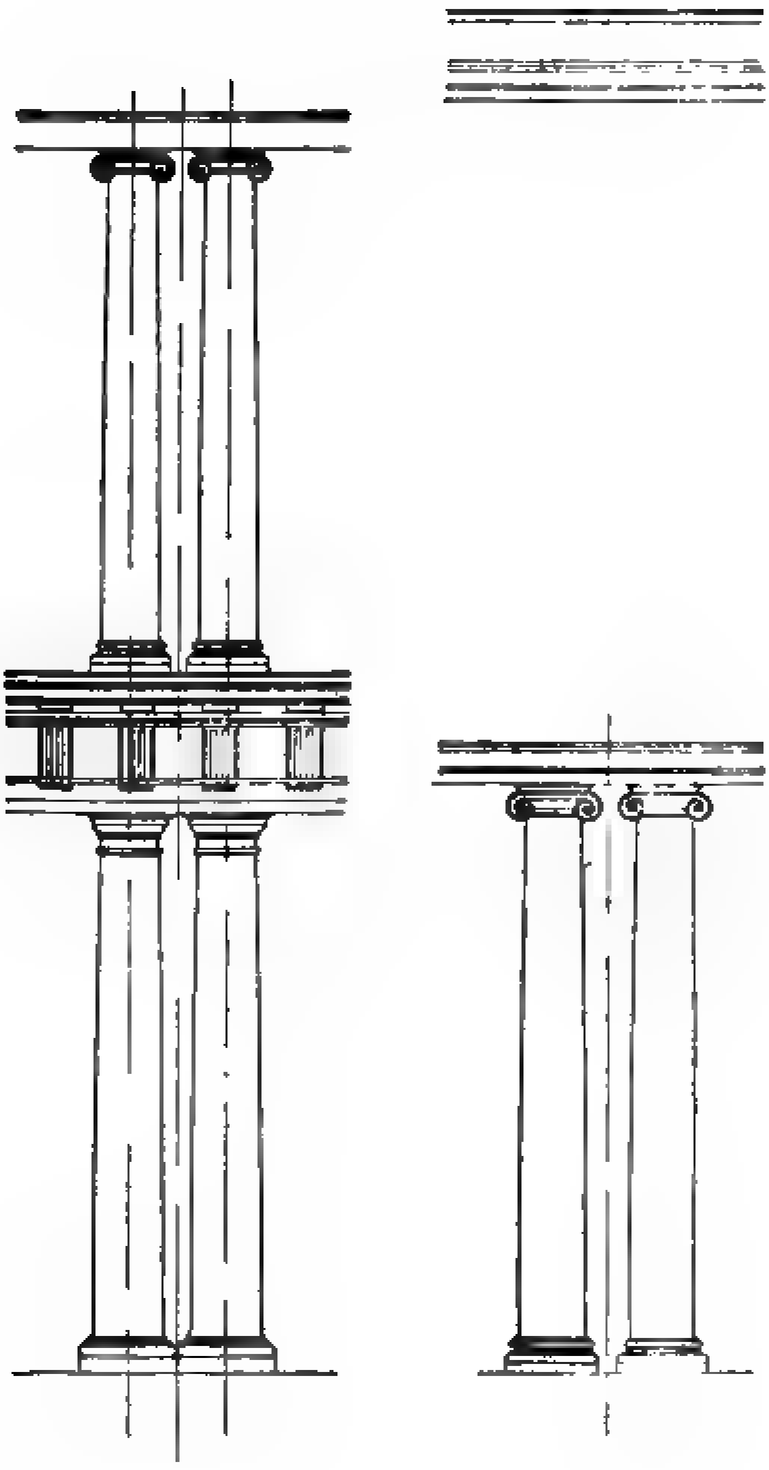
114. If the columns are set under alternate triglyphs so that there is one triglyph over the intervening space, their distance apart o. c. is two and one-half diameters. The intercolumniation is then one and one-half diameters, and is said to be *monotriglyph*. This is the most common arrangement. But if the scale is small, it is customary, at least at the principal entrance of a building, to have two triglyphs over the opening, the columns being three and three-fourths diameters on centers. The intercolumniation is then two and three-fourths diameters, and is called *ditriglyph*. Still wider spacing is employed when the architraves are of wood.

When two, four, six, eight, ten, or twelve columns are used in a colonnade or portico, it is said to be *distyle*, *tetrastyle*, *hexastyle*, *octastyle*, *decastyle*, or *dodecastyle*, according to the Greek numerals. Examples are found at Argos, Assos, Thoricus, and Pæstum of façades with an odd number of columns, three, five, seven, and nine, a column instead of an intercolumniation coming on the axis, giving *tristyle*, *pentastyle*, *heptastyle*, and *enneastyle* porticos. But in all these cases the entrances were apparently on the sides of the buildings, where there was an even number of columns.

SUPERPOSITION—PLATE XVII

115. Superposition is the placing of one order above another, as in the Roman amphitheaters and in many modern buildings of several stories. The more solid forms of the Tuscan and Doric are naturally placed below and the Ionic and Corinthian above. As the Composite is more vigorous, it is sometimes placed below the Corinthian. But in high buildings it is generally placed on the top story, its large details being better seen at a distance than are those of the more delicate order.

Even when the same order is employed in the different stories, it is advisable to have the upper columns of smaller diameter than those below and all the dimensions diminished accordingly, for the sake of lightness. But it is still more important to do this when different orders are superposed.



(a) (b) (c)

FIG. 64

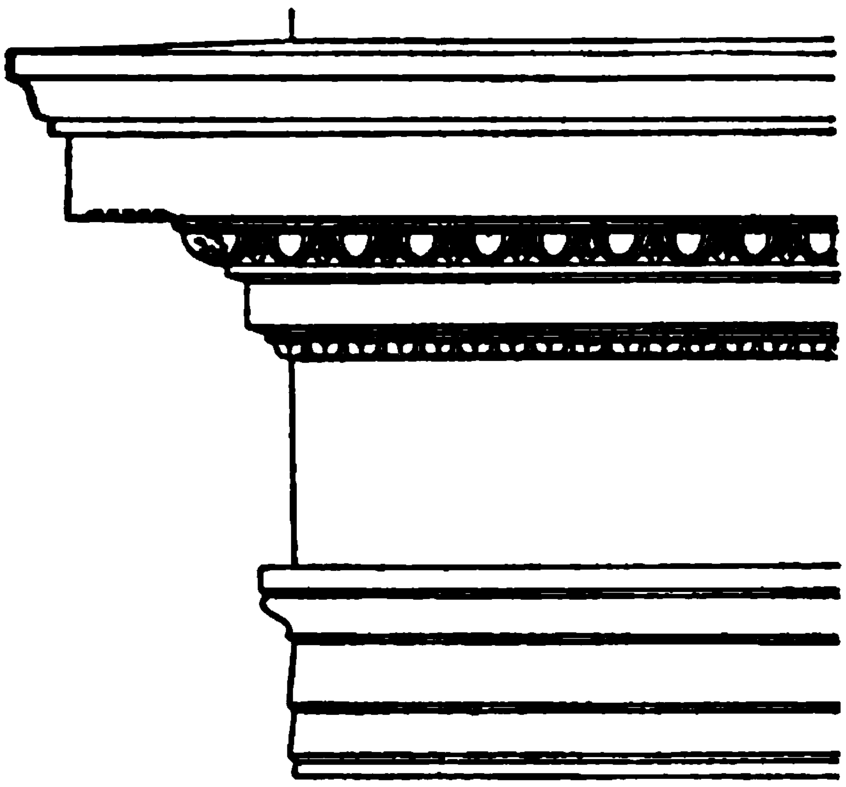
for otherwise the Doric and Corinthian stories would overpower the Tuscan and Ionic ones beneath. It is customary, accordingly, to make the lower diameter of each shaft equal to the upper diameter of the shaft below it, as if they were all cut from a single piece of tapering stone. This makes the scale employed in the second story five-sixths of that used in the first; in the third, twenty-five thirty-sixths, or about two-thirds; in the fourth, about three-fifths; and in the fifth, about one-half, if the five orders are employed in regular sequence. This makes the relative height of the orders in the successive stories to be as 7, $6\frac{2}{3}$, $6\frac{1}{4}$, $5\frac{4}{5}$, and 5, very nearly. The actual height of the stories themselves may be somewhat modified by the use of plinths and pedestals.

116. This system of superposition makes the distance apart of the columns in each story, when expressed in terms of their own diameter, six-fifths of that in the story below. A eustyle intercolumniation in one story thus exactly produces a diastyle intercolumniation in the story above, and a Doric monotriglyph intercolumniation, a systyle.

$$\left(\frac{6}{5} \times 3\frac{1}{3} = 4;\ \frac{6}{5} \times 2\frac{1}{2} = 3\right)$$

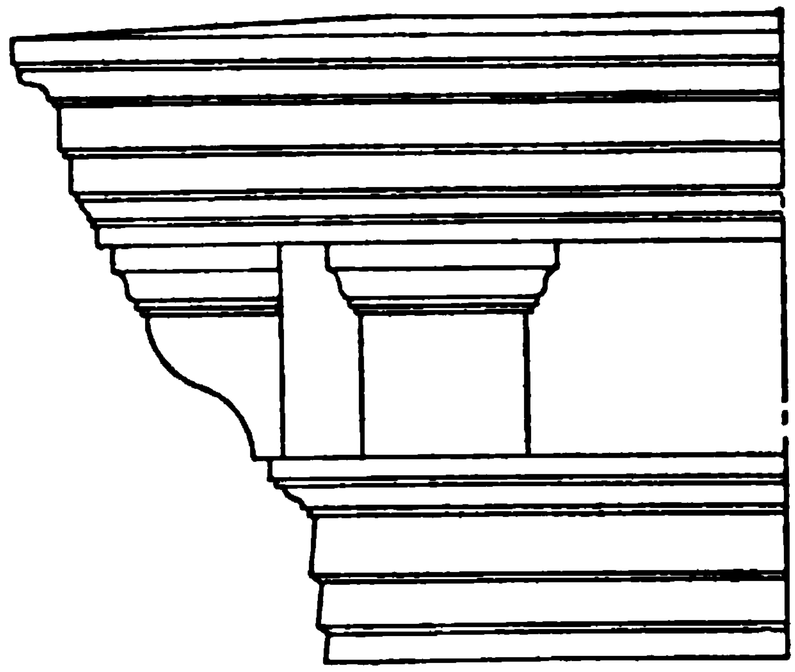
Coupled columns set one and one-third diameters apart, on centers, in one story, are, in the story above, one and three-fifths diameters on centers, and in the third story nearly two diameters on centers. This does very well for a sequence of Doric, Ionic, and Corinthian, as in Fig. 64 (*a*), but if the lower columns are Ionic or Corinthian, those above had better be set nearer together, the axis of the intercolumniation only being preserved, as shown in Fig. 64 (*b*).

With this exception, superposed columns are set so that their axes are in the same vertical line, when seen in elevation. But in profile, as seen in section, the upper ones are set back, the wall against which they stand generally growing thinner as it goes up, as shown in Fig. 64 (*c*). Since the columns themselves also grow smaller, it would not do to leave too much space behind them. The slightly pyramidal effect that this gives to a building of several stories is of value, as it prevents the building from looking top-heavy.



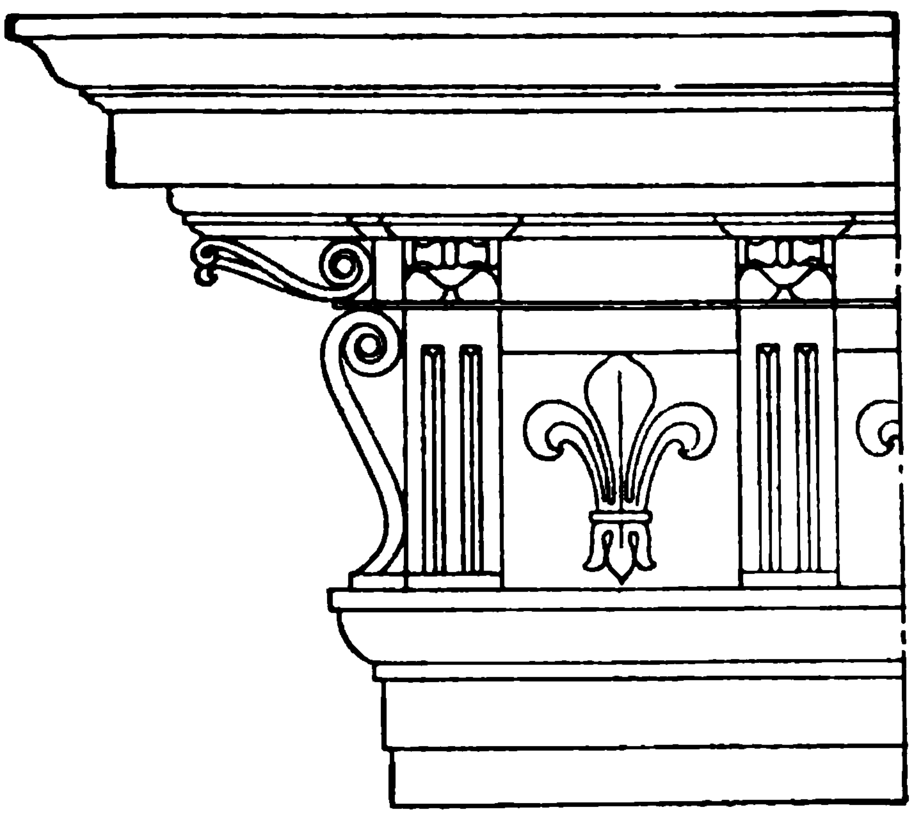
From the Pantheon, Rome

(a)



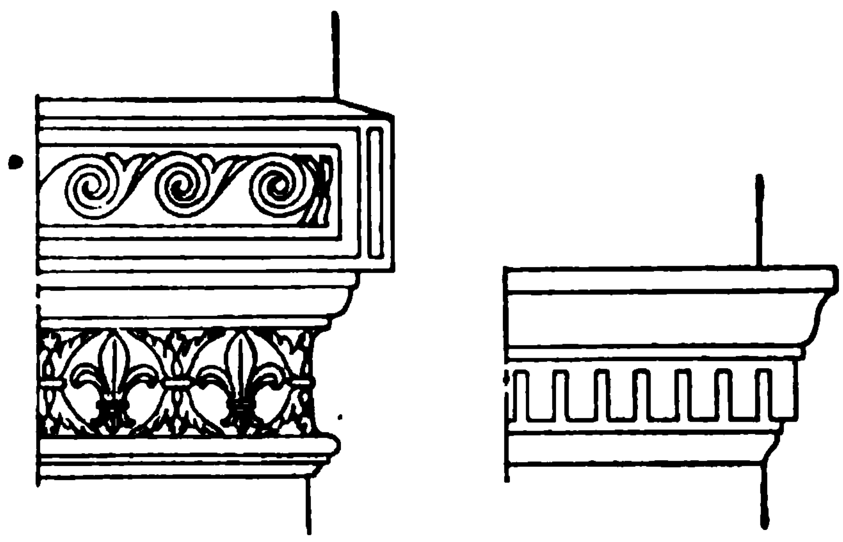
From the Fourth Order of the Coliseum

(b)



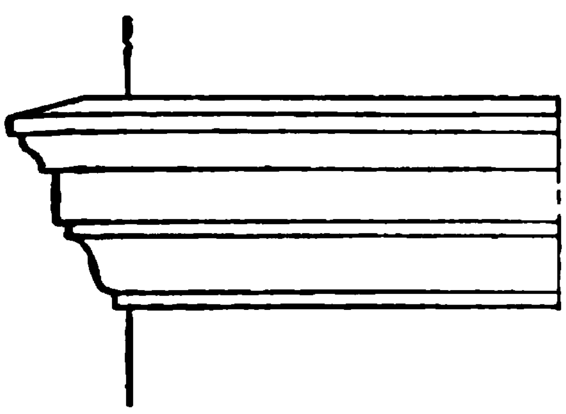
From the Villa Caprarola,
by Vignola

(c)



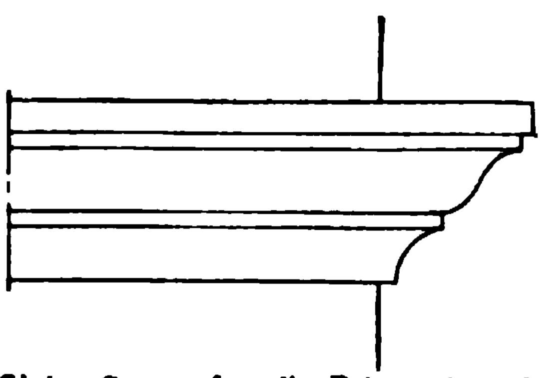
From the Farnese Palace
By San Gallo

(d) (e)



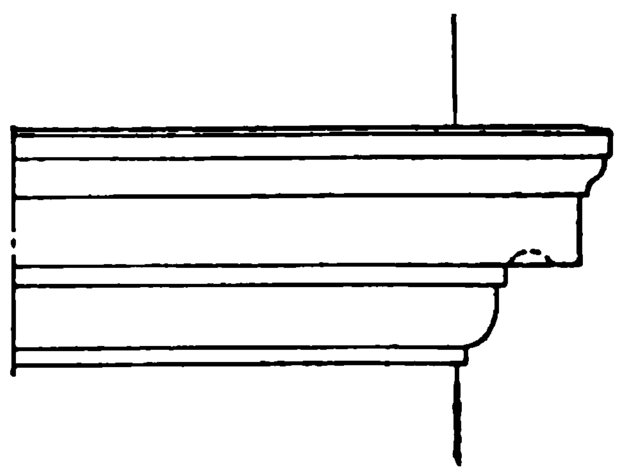
String-Course from the Strozzi Palace

(f)



String-Course from the Palazzo Giraud
By Bramante

(g)



String-Course from the Sachetti Palace
By San Gallo

(h)

FIG. 65

OTHER STYLES OF CORNICES AND STRING-COURSES

117. The five orders worked out by Vignola are generally accepted as a standard, though they are seldom exactly followed in practice, modern as well as ancient examples exhibiting a great variety in the forms and proportions of the parts. But familiarity with them is of great service in designing, since they can safely be employed on all ordinary occasions and in the earlier stages of architectural composition. Other types of nearly equal merit have been published by Alberti, Palladio, Serlio, Scamozzi, Sir William Chambers, and others, and a great variety of cornices, both with and without friezes and architraves, have been employed in ancient and modern times to crown and protect walls that were not decorated with columns or pilasters.

118. Many of these show blocks or modillions without any dentil course below, as on Palladio's composite cornice, and in many of them the dentil course is plain, forming what is called an *uncut dentil course*, as shown in Fig. 65 (*a*). In others, the brackets that support the corona are brought down so as to occupy the frieze, as in Fig. 65 (*b*). The most important of these is Vignola's so-called *cantilever cornice*, Fig. 65 (*c*), used by him at Caprarola. It seems to have been suggested by the mutules and triglyphs of his mutulary Doric.

Cornices, and indeed full entablatures, are often used as string-courses to separate stories, as in the Roman amphitheaters. However, it is customary to use instead a lighter form of small projection, somewhat like the cap of a pedestal, in which the cymatium and bed mold are often omitted and the corona itself sometimes diminished to a mere fillet, as in Fig. 65 (*d*), (*e*), (*f*), (*g*), and (*h*).

EXERCISE II

1. What is composition in architecture?

2. What is the difference between (*a*) repetition and continuity in designs? (*b*) Repetition and alternation?

3. (*a*) What is the purpose of moldings in architectural composition? (*b*) How may the same result be obtained without moldings?

4. How may architectural proportions be approximated through the use of diagonal lines?

5. Make a drawing of the complete Doric order with entablature and pedestal based on a column whose diameter is $1\frac{1}{2}$ inches.

6. Make a drawing of a Corinthian capital for a column whose lower diameter is four inches.

7. Make a drawing of the entablature of the Ionic order, wherein the column is two inches in diameter.

8. Make a drawing of a Greek Doric column and entablature based upon a diameter of two inches for the column.

9. Make a drawing of four Ionic columns, one inch in diameter, grouped under a pediment.

10. State the conditions that govern the designing of columns in intercolumniation and superposition.

5, 8, and 9 to be on sheets 12 in. × 18 in., 6 and 7 to be on sheets 9 in. × 12 in. All sheets to have a border $\frac{1}{2}$ inch wide all around, with the title neatly lettered within the border in some suitable space. Above the border the problem number to be lettered on the left and the sheet number on the right. Below the border, the date of completion to be lettered on the left, the name and class letters and number on the right, and the number of hours consumed in executing the drawing in the center. All drawings to be executed in pencil, but the border and exterior lettering may be in ink. When complete the large sheet to be folded once across and enclosed in the proper envelope with the small sheets and mailed to the Schools for criticism.

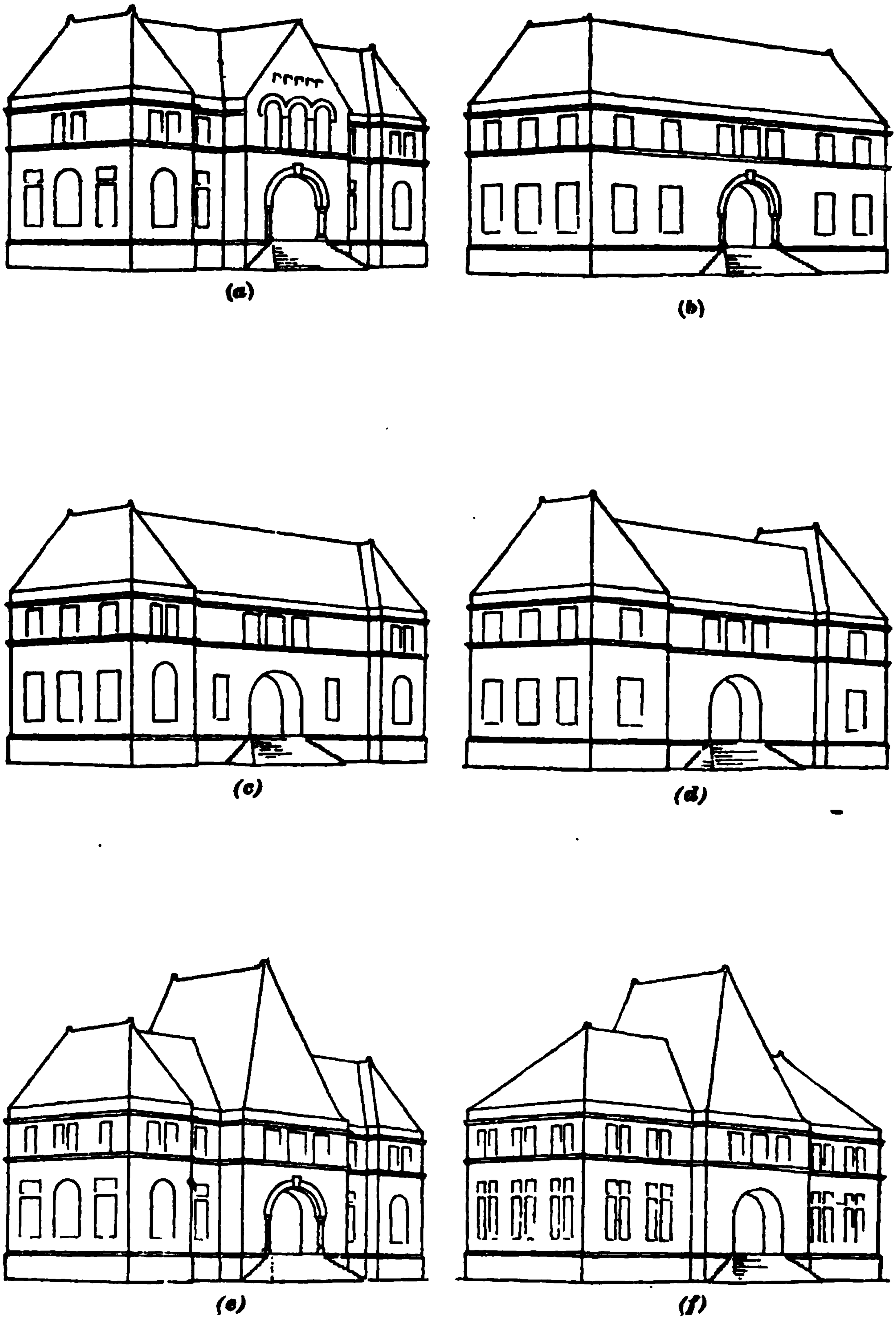


FIG. 66

APPLICATION OF PRINCIPLES

ANALYZING OF EXISTING DESIGNS

119. After a careful study of the principles of architectural composition and proportion, it is well to be ever on the lookout for buildings that express various groupings heretofore referred to, and also to analyze them and try to decide whether the treatment is the best that could be accomplished. By thus taking advantage of the better groupings he observes and avoiding the unsatisfactory ones, the student will instinctively select a system to govern his own designs. A memorandum book in which sketches of good examples of architectural grouping can be made from time to time will also be of great value, as he can then work up these sketches at his leisure and experiment with the designs in the endeavor to improve on them.

120. Take, for example, the building shown in Fig. 66 (*a*). Here is expressed a group of three—two pavilions connected by a link to the central gabled mass, which is the most important. With a sketch of this laid out as at (*a*), the variations can be studied by means of a piece of tracing paper. This paper can be laid over the design so as to sketch out the principal details, and then their grouping can be experimented with.

The fundamental base from which this design is evolved is shown in (*b*). Here is expressed a single mass, with its windows grouped to suit the requirements of the interior, and a roof over the whole. There are no dormers or other openings above the cornice, so that almost any liberty can be taken with the roof composition to secure a desirable effect. The grouping in (*a*) is not wholly satisfactory, as there is too much uniformity in the masses. The central

mass, though larger than the other two, does not seem to dominate them sufficiently. A group of two with a connecting link, as shown in (*c*), might be better, but the pavilions seem to be too narrow in proportion to the link connecting them; and by increasing their width, as at (*d*), the treatment adds to the importance of the two pavilions, while according to the original building, in (*a*), it is evident that the central mass should be the most important. The central mass should therefore be increased in importance, as its lack of assertion is the chief fault of the original composition. By raising the roof and hipping it back, as in (*e*), this effect is attained, and there is no longer any doubt as to the importance of each mass. The secondary masses, however, have lost in value through the increase in importance of the central mass, and if this is at variance with the purposes of the design, it might be well to suppress the secondary masses entirely and treat the composition as a single mass with two auxiliary masses, as shown at (*f*).

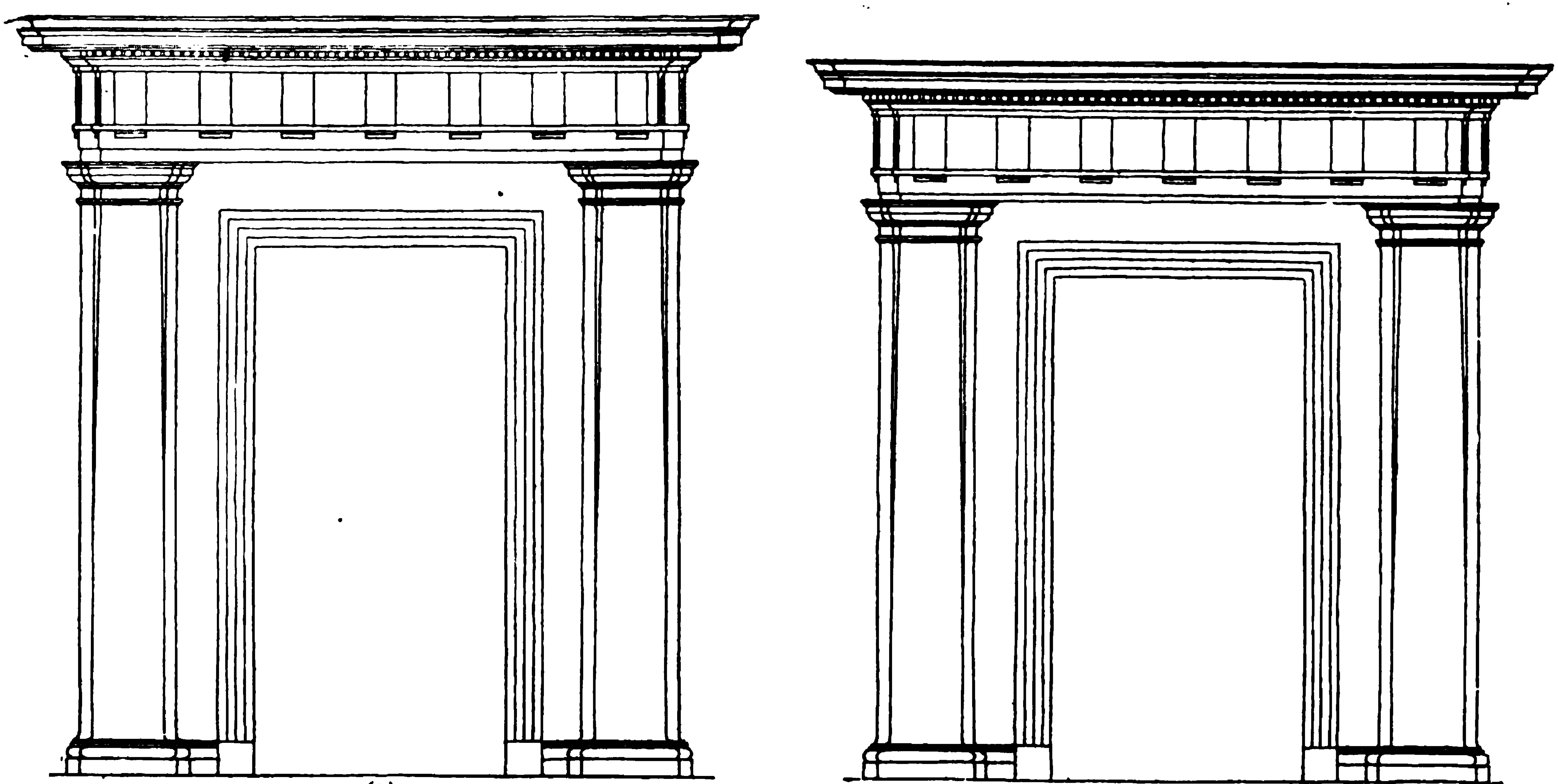
Here, then, are shown six methods of treatment that do not affect the plan materially and depend for effect mostly on the handling of the roof. A slight variation of the window openings would be necessary in some places, but no change great enough to require any alteration of the plan. Such a design is susceptible of almost unlimited changes, and frequent exercises of this kind afford excellent practice for young designers.

INTERCHANGING OF ORDERS

121. Another practice that should be indulged in frequently is the interchange of the classic orders. For example, make a drawing from a photograph of some such building as the Vendramini Palace or the Gaston d'Orleans wing of the château at Blois, but substitute some other order for the one in the original design and alter the design accordingly. The diameters of the columns will determine their lengths, and this will influence the heights of the stories; or, if the diameters are varied to suit the lengths assumed, the change will affect the spacing of the windows.

(a) (b)

FIG. 67



(a) (b)

Fig. 68

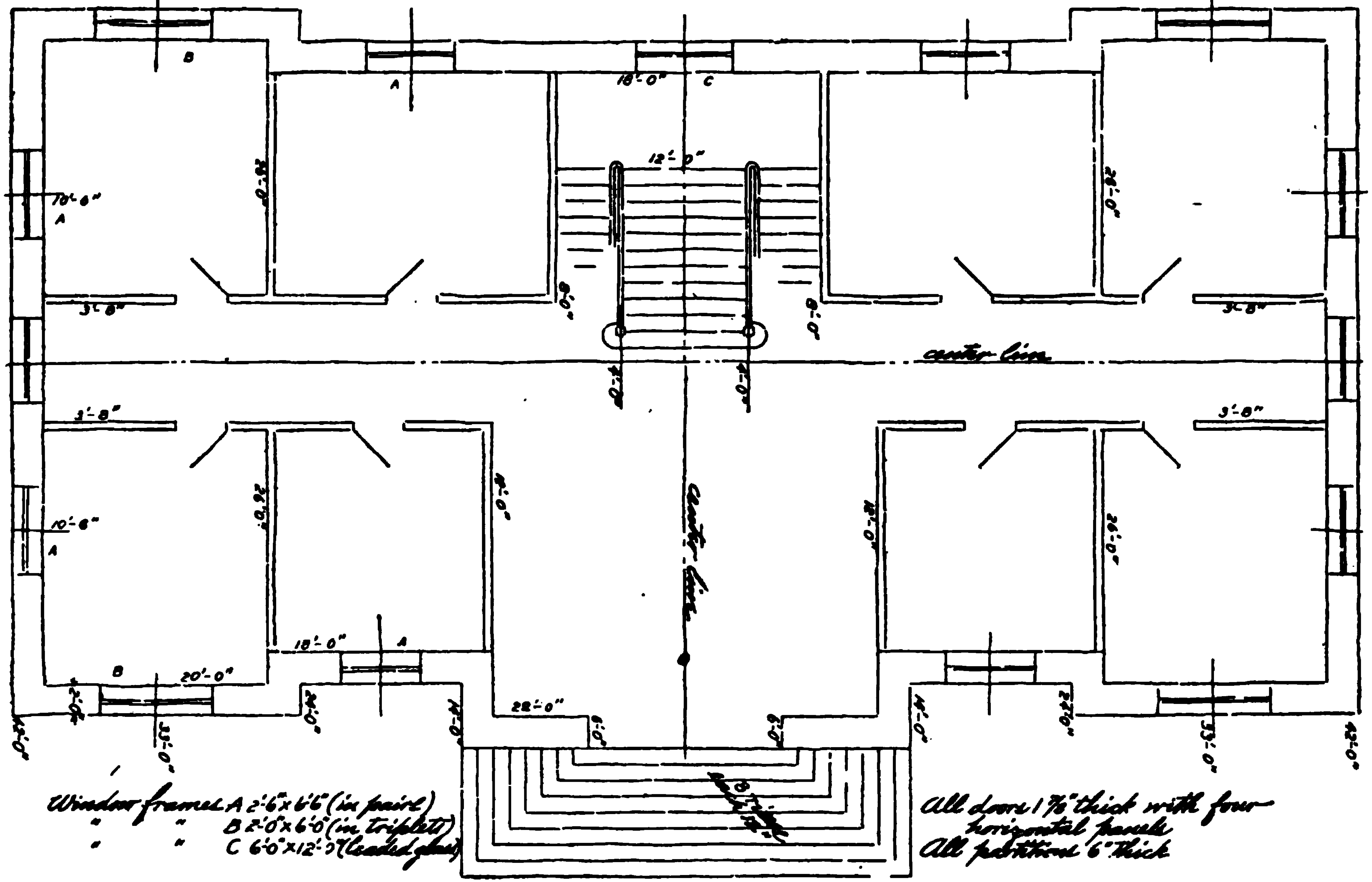

center line
center line
Window frames A 2'6"x6'6" (in pairs)
" " B 2'0"x6'0" (in triplets)
" " C 6'0"x12'0" (leaded glass)
All doors 1 3/4" thick with four horizontal panels
All partitions 6" thick
42'-0"
33'-0"
26'-0"
18'-0"
12'-0"
3'-8"
10'-6"
20'-0"
22'-0"
14'-0"
6'-0"
8'-0"
4'-0"

FIG. 69

As only the diameter of the column has to be known in order to draw out the entire order, the beginner can construct the elevation of a building from a brief description. The student should write out descriptions of buildings that he frequently sees, and then endeavor to make a measured drawing of a building from the description he has written. He should also take the opportunity as frequently as possible of actually measuring up a building and then laying out a drawing of it. If an entire building is too great an undertaking, he should select a detail of it, such as the entrance, a window, a gable, or some other section.

122. Measuring Up.—In measuring up a building for the purpose of making an actual drawing, everything should be figured from a given point, as this will render errors in measurement less likely to affect the entire drawing. If each detail is measured separately, a single error is likely to throw all the details out of place.

In Fig. 67 (*a*) is shown a rough, freehand sketch of a doorway, of which all the measurements have been taken from two given base lines. All the vertical measurements are taken from the floor, while all the horizontal measurements are taken from the center line of the left-hand column. In (*b*), however, the same doorway has each member figured separately, and there is an error in the figures showing the space between the door head and the entablature of the order. If a drawing were to be made from this figured sketch, all the details above the door head would be out of place, as shown in Fig. 68 (*a*); whereas, if a drawing were made from Fig. 67 (*a*), and the same error existed, the only detail out of place would be the lower line of the entablature, and this would soon show itself, because the architrave would appear too narrow.

123. The same method should be followed in surveying or measuring up the plan of a building, whether for alterations or for the purpose of making a diagram of it. In Fig. 69 is shown a rough sketch of a floor plan. Two center lines are taken on the axes of the two corridors, and

the partitions are figured on each side of these axes. The dimensions of the window and door openings are then taken separately, and a written memorandum is made of the details of each. Where lighting fixtures exist, they can be located by figures showing the distances of the outlets from two walls of the room, or, where the outlets are in the side wall, they can be figured from the nearest wall and from the floor. Radiators can be drawn in place and the position of the riser pipe figured, while plumbing fixtures need simply to be indicated and the standing lines located with figured dimensions. Where more detail is required, such as the form and character of the trim, separate sketches should be made and all the moldings carefully profiled.

The axis from which the general measurements are taken need not be in the center of the structure, but can be located at any convenient place from which all measurements can be easily made. If the axis is changed for any reason while the survey is progressing, the new line should be carefully figured relative to the old one, so as to avoid errors. If measurements are found to have been omitted, and a return to the building becomes necessary, the additional figures should be put on the first sketch, thus avoiding the annoyance of handling two or three memoranda while plotting the plan.

124. The beginner should cultivate the habit of observing the details of the design of any building. This habit is best acquired by attempting to write out a complete description of the building from a photograph or from the edifice itself, and then to make a drawing of the structure from the description as written. Any omission of important details will at once become evident, as the drawing cannot be completed without them. For example, take the Arch of Titus, Fig. 84, *History of Architecture and Ornament*, Part 1. A description of it would be somewhat as follows:

A triumphal arch consisting of a mass of masonry pierced with a single arched opening, and embellished with attached columns, pedestals, and entablatures of the Composite order.

The entire width of the monument measured between the center lines of the outside attached columns is twenty diameters of one of its columns, and is arranged as follows: On each side of the opening stands a mass of masonry that together support the superstructure. At the sides of these masses are attached columns five diameters apart, on centers. A continuous pedestal on which the columns rest extends across the face of each flanking mass, and an entablature above the columns extends across and around the entire monument from one mass to the other. This entablature breaks out and returns around the end columns, but breaks out entirely across the space over the arch between the two flanking masses. Above the entablature is an attic, or superstructure, bearing an inscription tablet. This attic is about one-third the height of the entire mass below it, is molded like the pedestal, but has pilasters broken out on each end, corresponding to the broken entablature below, and a tablet raised in its center, corresponding in width to the archway of the monument.

In the center between the two flanking masses is an arch with an architrave around the face of the vault between the imposts, supported on two pilasters that project into the opening about three-fourths of a diameter beyond the lower part of the columns. The height of the arch in the center is one and one-half times the width between the pilasters, and a keystone in the center extends up to the under side of the horizontal architrave of the order. The astragal of the capitals of the columns is carried across the flanking masses of masonry between the columns.

This description will be found sufficient for making a drawing of the elevation of the Arch of Titus shown in Fig. 84, *History of Architecture and Ornament*, Part 1. Any assumed dimensions can be taken as the diameter of the columns, and the design can be worked out from the proportions of the Composite order and the dimensions given.

EXERCISE III

1. **Sheet I.**—On a scale of $\frac{1}{4}$ inch to the foot, draw a Roman Ionic temple in accordance with the following description: The plan shows four columns across the ends and seven down the sides. The columns are 2 feet 6 inches in diameter, and are spaced three diameters apart, center to center. The bases of the columns stand on a *podium*, or continuous pedestal, extending entirely around the temple, except in front, where it is broken to permit a flight of steps to the floor of the temple, which is even with the top of the podium. The width of the steps across the front is seven and one-third diameters, and nine of them are required to reach the floor level of the temple. The naos, or cella, of the temple is shorter than the columnar enclosure, as the roof is carried out two columns beyond the front so as to form a pronaos, or porch. The cella therefore is nine diameters wide and fifteen diameters long, and the columns on the sides and rear of the temple are attached to the walls, making the structure pseudoperipteral.

2. **Sheet II.**—Draw the front elevation of the preceding temple, showing a pediment over the entablature and an entrance between the central columns six diameters high.

3. **Sheet III.**—Write a complete description of any one of the following buildings so that a drawing can be made from it: Colosseum; Arch of Constantine, Rome; Petit Trianon; Madeline, Paris; Banquet Hall of Whitehall Palace, Royal Exchange, London.

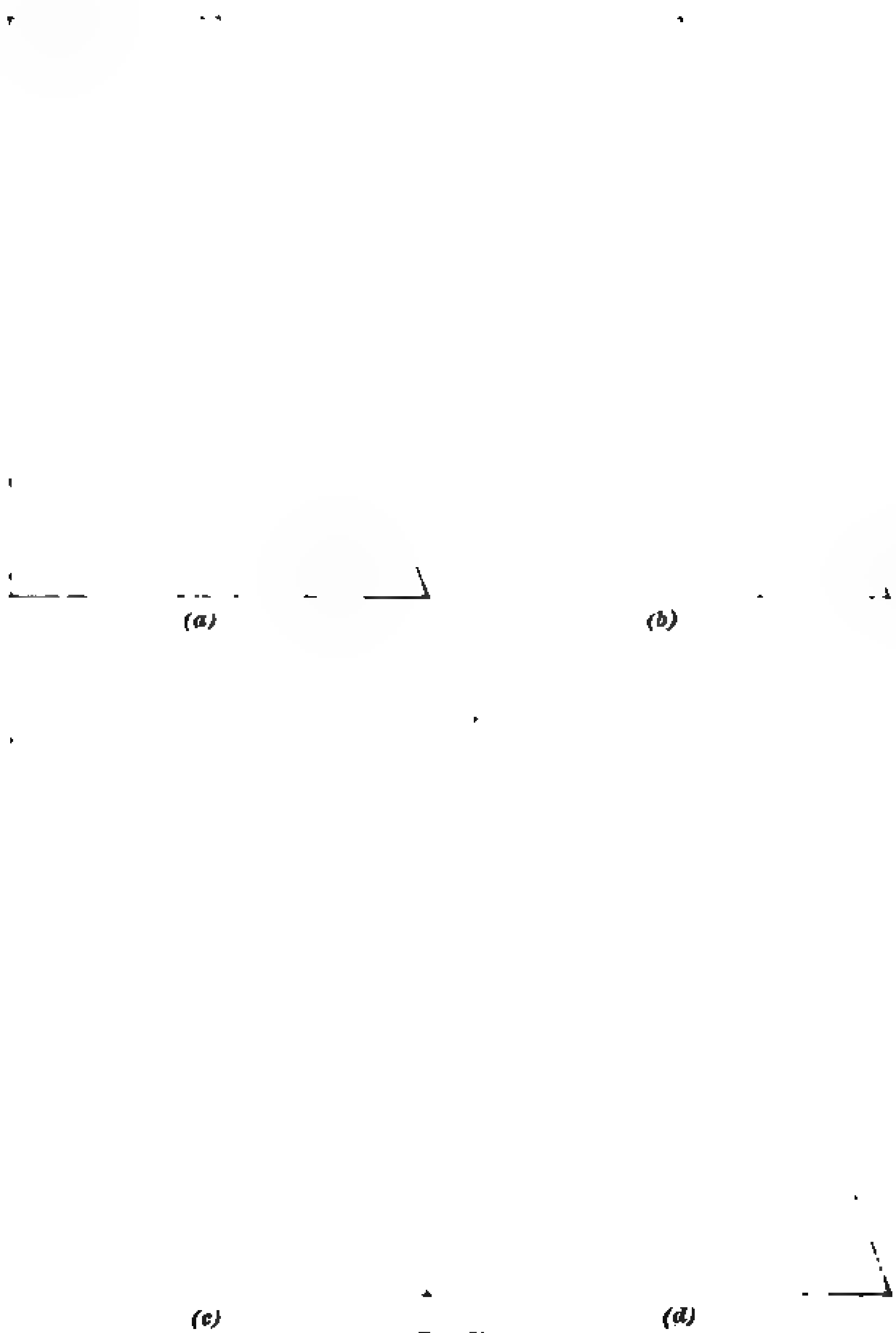


FIG. 70

PROBLEMS IN DESIGN

125. Designs for monumental and important buildings are usually laid out in accordance with certain required conditions that constitute the problem that the architect is called on to solve. These requirements are never twice alike, so that every problem that confronts the architect is a new one, but practice and experience make each solution simpler, so that as soon as the conditions of the problem are stated, the experienced architect conceives an idea of the way he will set out to solve them. The various architectural magazines publish from time to time advertisements of competitions for various public buildings, and the beginner should occasionally procure the conditions of these competitions and experiment in planning. His solution of the problem should then be compared with the accepted plans, which are sure to be published sooner or later. A few of these problems and their solution will serve to illustrate the process by which the final results are obtained.

126. Problem in Design of a Bank Building.—A large and important banking corporation desires to erect a new and imposing building to be used solely for its own purposes. Provision is to be made for eight tellers' windows for the transaction of ordinary business, and for at least four extra windows for emergencies. There are to be private offices for the president and the cashier, each to be about 225 square feet; a board-of-directors' room of not less than 350 square feet; a coat room and a lavatory for the clerks and bookkeepers; and separate toilet rooms for the officers and customers. At some convenient spot accessible to all the officers and tellers, a fireproof vault is to be provided, the floor area of which is to be not less than 100 square feet. The building will stand on a corner lot 50 feet wide in front, 140 feet deep, and 100 feet wide in the rear. The front wall must be 25 feet back of the building line on the 50-foot front, and 10 feet back of the line on the 140-foot side. The lot is not rectangular, but of the form shown in

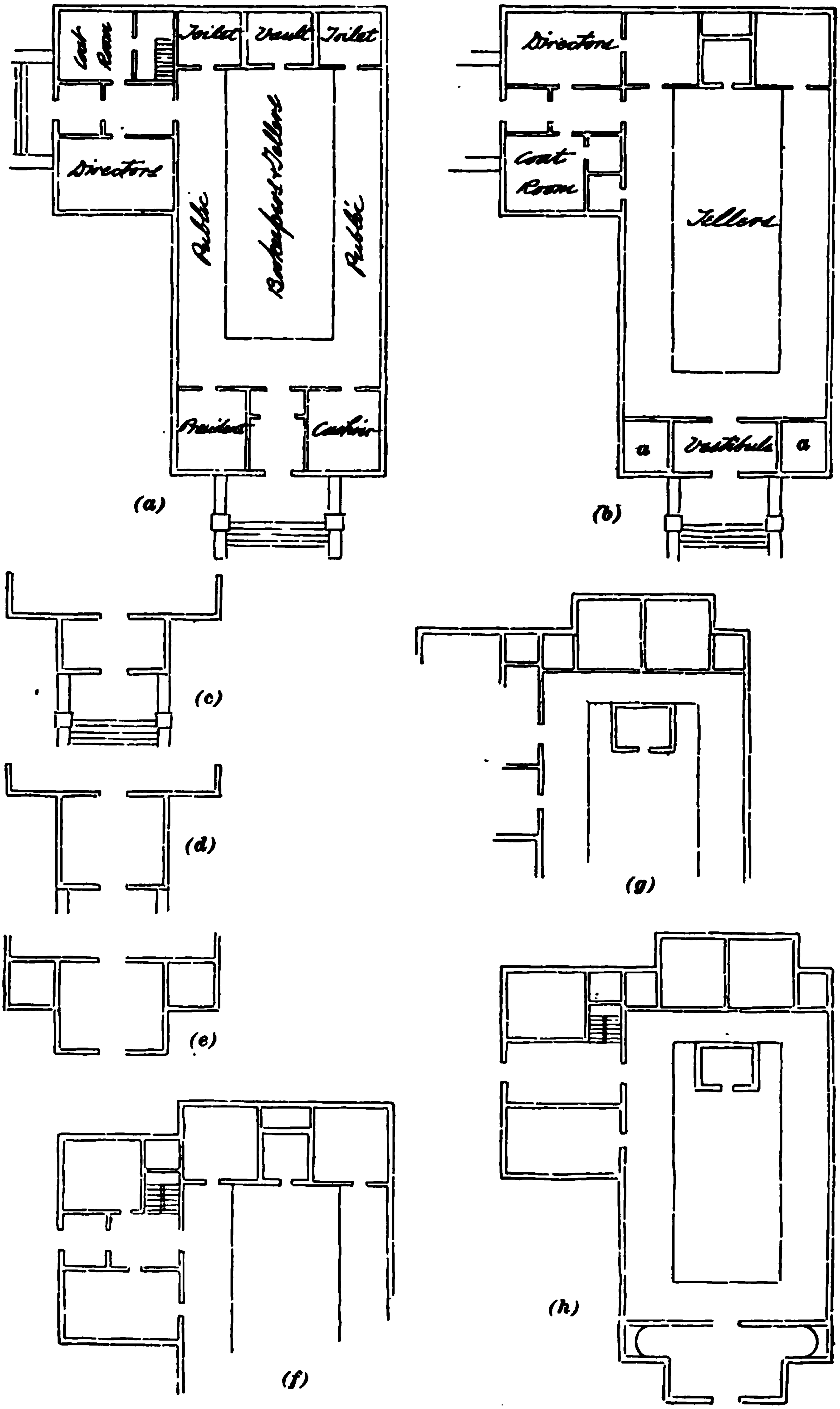

Coat Room
Toilet
Vault
Toilet
Directors
Public
Bookkeepers & Tellers
Public
President
Cashier
(a)
Directors
Coat Room
Tellers
a
Vestibule
a
(b)
(c)
(d)
(e)
(f)
(g)
(h)

FIG. 71

Fig. 70 (*a*). The arrangement of the parts and the exterior treatment are left entirely to the discretion of the architect.

127. The first problem arising in the arrangement of this plan is the placing of the tellers' windows so that they will be easily accessible to the public. This problem presents two solutions: the windows can be arranged around the walls, so as to get the benefit of plenty of light, with a large open space in the center for the use of the public; or, they can be placed in the center with a passageway around them. The latter treatment demands a skylight, but it enables the entire clerical force to be together, and is therefore desirable in this case.

128. Since the plot on which the building is to be erected is irregular in shape, it is hardly practicable to have the walls of the building conform to it in plan. The largest rectangular plan that can be erected on the plot, within the 25-foot reserve, is shown in Fig. 70 (*b*), but this leaves a large triangular space of unused ground that does not enhance the building any, as its greatest depth is toward the rear. The most conspicuous angle of the building would be that at the intersection of the two streets, and it would be well if the excess space were at that end.

A wing forming an auxiliary mass can be carried out from the main structure, as in (*c*), thus reducing the size of the triangular waste space, or if a symmetrical plan be demanded, a wing can be carried out from the middle of the side, as in (*d*), but this leaves matters quite as bad as they are in (*b*). The scheme shown in (*c*) would leave a triangular plot embraced between the wings of the building, which could be rendered pleasing in connection with the exterior treatment, and a porch on the side pavilion could be made to utilize the major part of the other triangle. If space would permit, however, and a smaller area would satisfy the demands of the problem, all walls could be drawn back from the lot lines and a small grass strip could be carried around the two sides, as shown by the white space in (*c*).

129. All the suggested arrangements are necessities dependent on the working out of the plan, but starting with the scheme shown in Fig. 70 (*c*) as a basis the rough arrangement is sketched out as shown in Fig. 71 (*a*). Here, the offices for the president and the cashier are placed on each side of the entrance. The vault is placed against the center of the rear wall, with toilet rooms each side, while the enclosure for the clerical force and tellers is railed off in the center. The directors' room and other details work out nicely in the wing, but the tunnel-like vestibule detracts from the impressiveness of the entrance. Reversing the plan, and placing the officers' rooms in the rear, as in (*b*), improves matters so far as the entrance is concerned, but it necessitates the changing of the toilet rooms to the wing and creates two spaces *a* that are apparently of no use.

The spaces *a* could as well be removed, thus giving a projecting entrance and leaving more grass space around the prominent angle. Studying this entrance by itself, as in (*c*), after the removal of the angles *a*, develops the fact that the vestibule is still too small for so impressive an interior. Enlarging the vestibule by itself, as in (*d*), renders the projection excessive, and it is found advisable to resort to a compromise of the arrangement shown in (*b*) and plan the entrance as in (*e*). For the present, this can be left and the rear studied out more carefully.

130. The arrangement shown in Fig. 70 (*b*) is likely to leave the back rooms gloomy and unventilated, except through the skylight. The wing can be moved forwards as in (*f*), so as to get a window in the president's office, but there is still no ventilation for the cashier's office. This suggests breaking the angles as in front and placing the offices directly adjacent, as in (*g*). The vault is now removed from the rear and built entirely within the building. This is an advantage, as being exposed on all sides, the vault secures additional burglar protection. The public toilet rooms fall naturally in the angles of the building, as shown, and all promises to work out well.

The wing can now be divided to provide a coat room and a lavatory for the clerical force. The directors' room will open into the banking room, and the stairway to the basement and to the janitor's quarters can be fitted between the coat room and the main structure, as in (*h*). The vestibule can be worked out to include a couple of niches for statuary where the waste

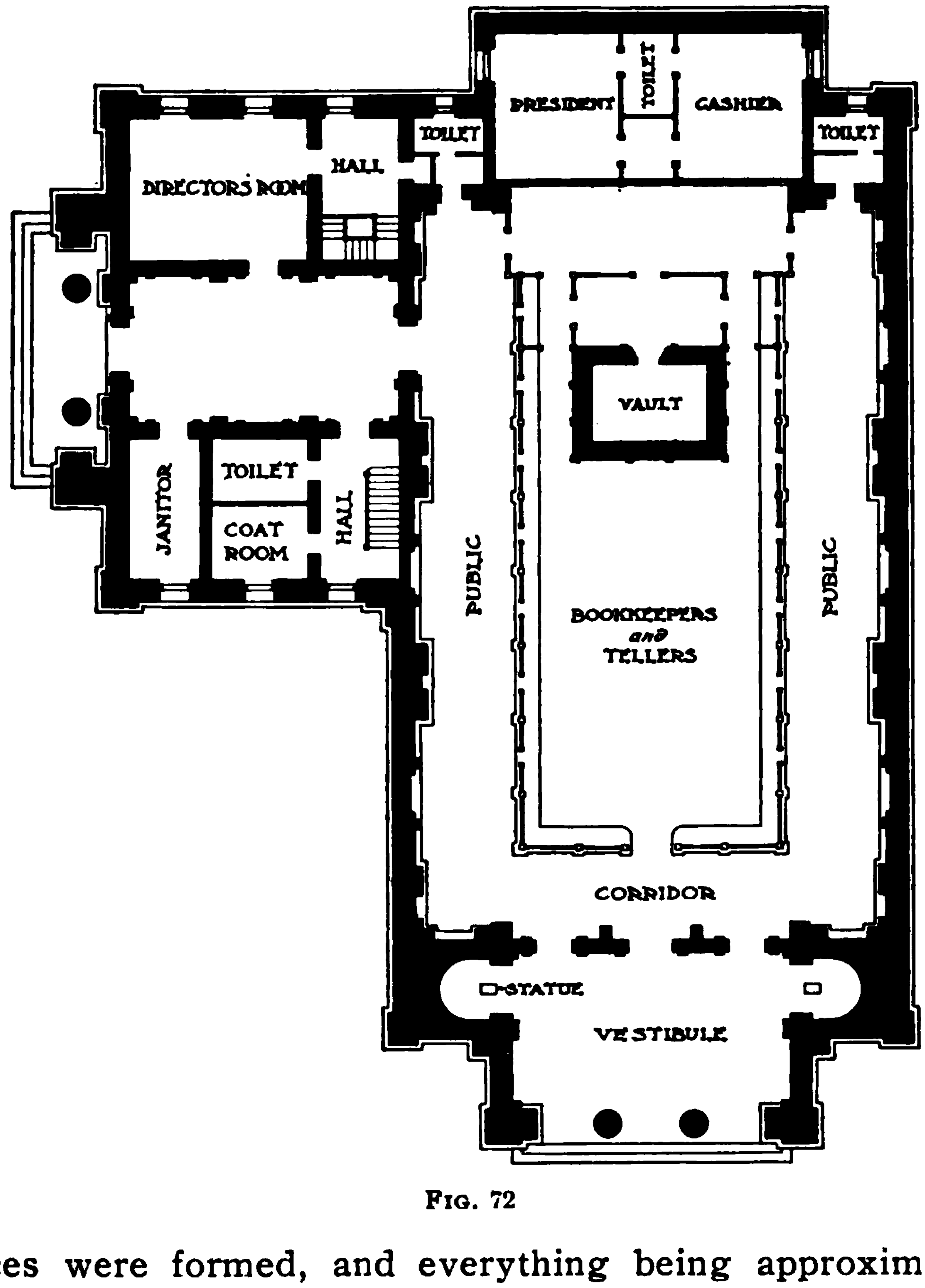


FIG. 72

spaces were formed, and everything being approximately satisfactory the whole can be laid out to scale as in Fig. 72.

The offices of the president and the cashier are 16 ft. × 16 ft. each, or 256 square feet. The directors' room is 14 ft. × 26 ft., or 364 square feet. There is ample room for the

tellers and clerical help, and the plan can be left in this state while the elevations are being worked out.

131. Fig. 73 shows a rough sketch for the main front. It is a simple, classic treatment with a projecting porch, and seems in every way to be in keeping with the dignity of the design. The lighting of the interior can be provided either by means of a skylight in the center or by openings in the parapet wall around the hipped roof, according to which scheme works out with the development of the design.

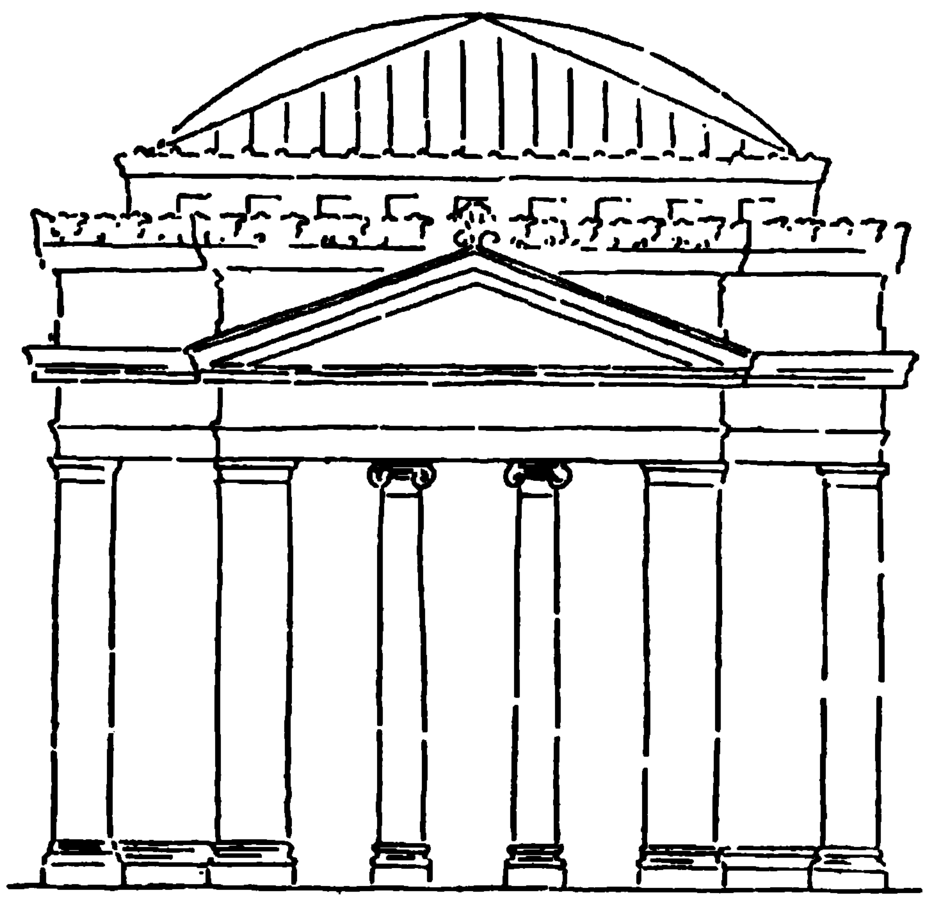


FIG. 73

Details of the elevations must be sketched and resketched, precisely as was done with the plan, and more changes then made in the plan where necessary to permit the best combined conditions. The columnar treatment of the portico suggests a similar interior treatment, and note of this must be made on the plan.

In Fig. 74 is shown a sketch of an elevation of one side of the interior. This decorative scheme requires that the pedestals under the pilasters shall be shown in the plan, as well as the projection of the main pilasters and inferior order supporting the pediment over the tablets. The position of these details is therefore indicated in the plan, Fig. 72.

Finally, the entire problem is worked out and the final plans and elevations are made and rendered, as shown in Figs. 77 and 78.

132. Dwelling Houses.—It does not always follow that the simpler and more modest the problem, the easier

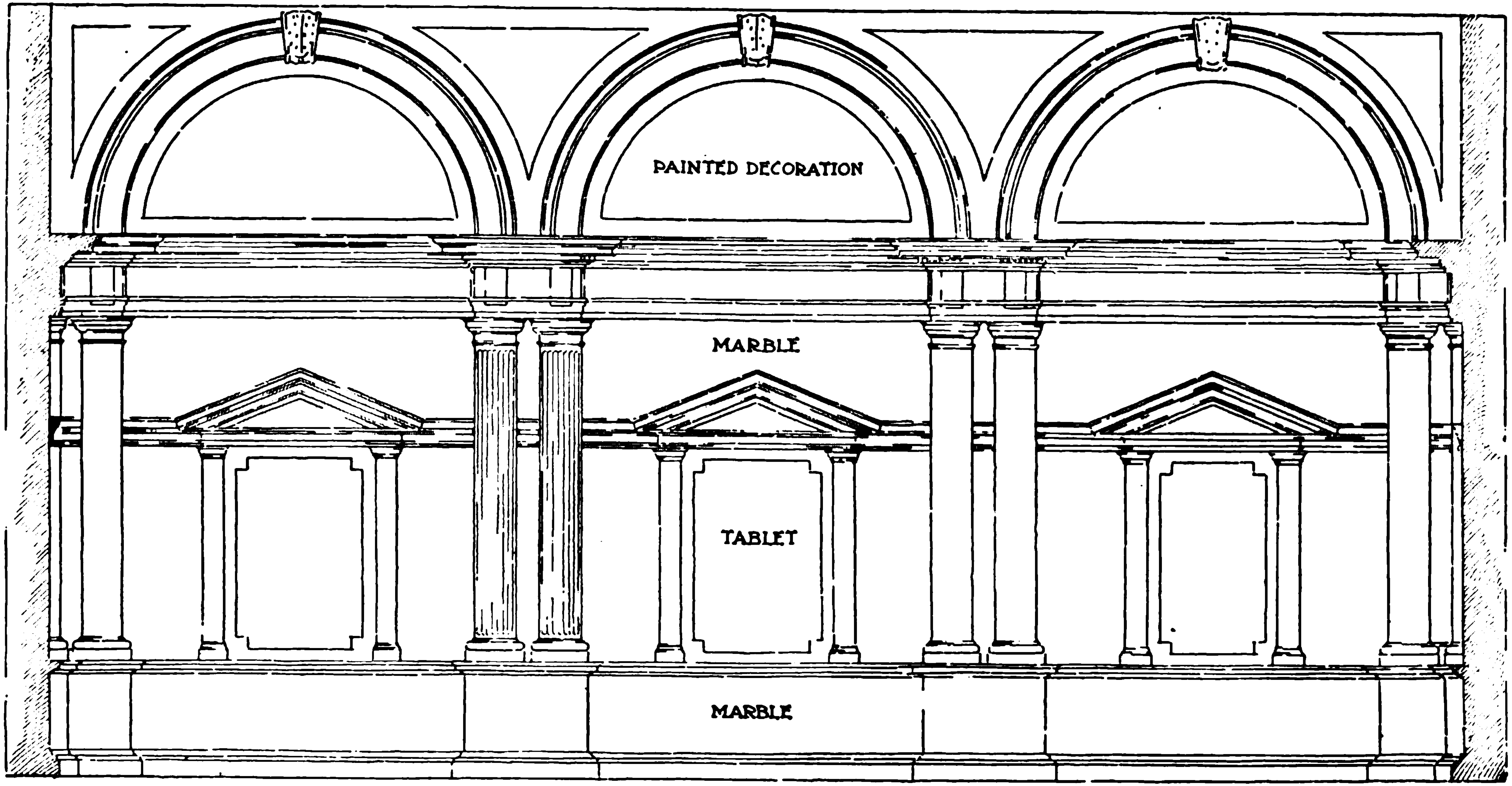


FIG. 74

it is to work out. On the contrary, there are some small problems exceedingly difficult to solve in a satisfactory way. Among these is the low-priced frame residence. Such a dwelling must have a kitchen, a dining room, and a living room on the first floor, a bathroom and sleeping rooms on the second floor, and a certain amount of attic room. To get all these rooms within the limits of the set cost is often difficult and frequently impossible. A good way to plan within these limitations is to determine at the outset what the plan area shall be. This can be done by assuming that the class of dwelling required costs a certain amount per cubic foot, and then dividing this amount into the building-limit price, in order to determine how many cubic feet can be enclosed within the proposed residence. This total of cubic feet divided by the average height of the building will give the plan area.

For example, a house containing two stories and an attic is to be built for $4,000. As a rule, the first-story ceiling should be at least 10 feet in the clear and the second-story not less than 9 feet, while the attic should be 8 feet and the cellar 7 feet. Allowing 12 inches to the thickness of each floor between the stories will give a total of 38 feet for the height of the building from the cellar floor to the top of the attic ceiling beams. Now, assuming that this class of dwelling can be built at 10 cents per cubic foot, for $4,000, it will be possible to build 40,000 cubic feet, and $40{,}000 \div 38 = 1{,}053$ square feet. The next process is to try to arrange the required rooms of the required sizes within the required area. Assuming the dining room to be 12 ft. $\times$ 16 ft., or 192 square feet, the kitchen, 12 ft. $\times$ 14 ft., or 168 square feet, and the living room 15 ft. $\times$ 20 ft., or 300 square feet, there is in all 662 square feet of plan, thus leaving 391 square feet for halls, passageways, stairs, etc., which seems reasonable.

FIG. 75

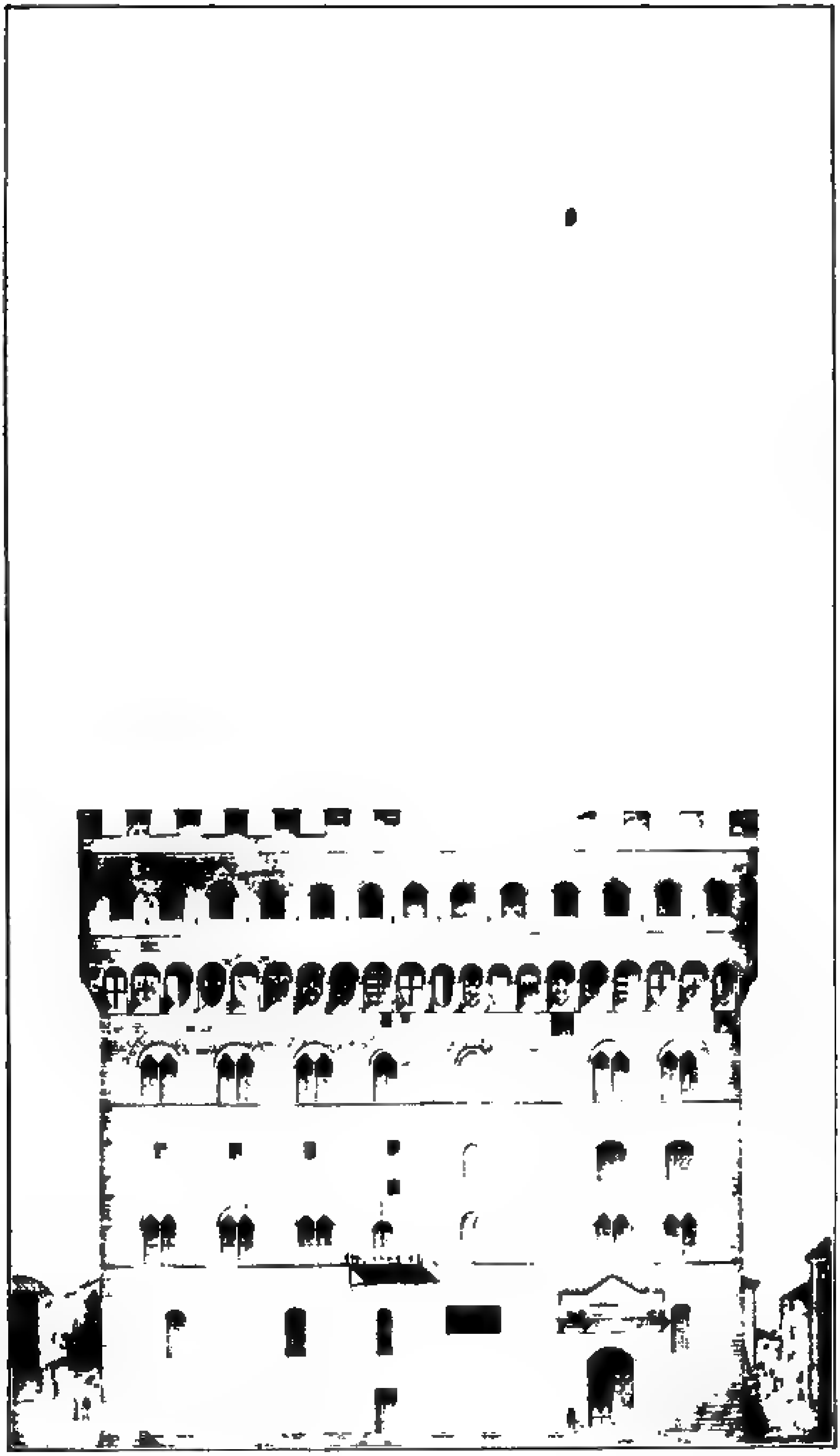


Fig. 76

WASH DRAWINGS

133. In order to become familiar with the effect of **wash work** in plain elevations, it is well to make studies of existing façades, either from written descriptions, as suggested in Art. **124**, or from measured sketches, as described in Art. **122**. The latter method is far preferable, as it gives practice in architectural surveying, drawing, and rendering.

In the large foreign and American architectural schools, the students that attain a high average in their studies are awarded traveling scholarships that give them opportunity for this line of study. The traveling scholar spends a year or more studying the historic buildings of Europe, and making measured drawings of them. These are preserved for future reference and serve to show what use he has made of his time.

134. In Fig. 75 is shown an elevation of St. Mark's Library, in Venice. This design was made from measured drawings and rendered in wash by a student of the National French Architectural School. The student in this case has undoubtedly measured every minute detail, in order that there could be no error, and every piece of carved work is as accurately rendered in the drawing as it was executed in the structure itself. The amount of time required for the completion of a study like this is very great; but at the same time it is of little importance when compared with the immense value of the experience attained in searching so carefully into the minute details of a recognized design of merit and reproducing them on the spot.

135. Another study by a traveling scholar is shown in Fig. 76. This design was made by an American student, and is a measured drawing of the front elevation of the Palazzio Vecchio at Florence. While made with no less care and drawn with equal accuracy, this drawing does not appear so much like a mechanical reproduction as does that of the French student. The study in Fig. 76 pronounces itself plainly as a wash drawing of a building façade, show-

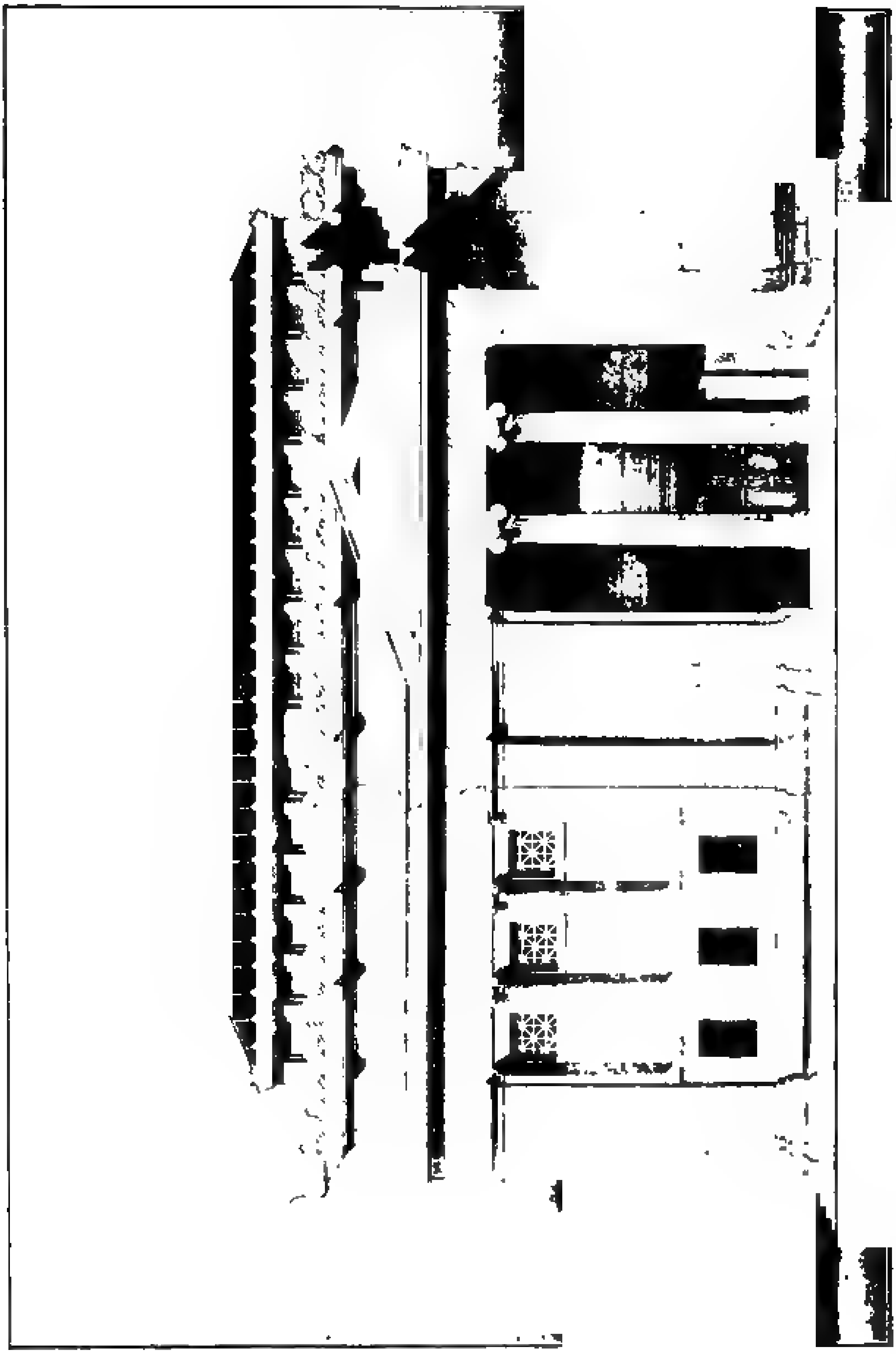


Fig. 77

FIG. 78

Generally speaking, 15 feet is about as narrow as the dining room should be made. The length of the room depends entirely on the length of the table when used to its fullest capacity, 20 feet in length making a good proportion with the width just given. A reduction of these dimensions is a step toward economy but a sacrifice of convenience. It should be borne in mind that a house planned with roomy, well-lighted dining apartments adds materially to the cheer and comfort of the occupants.

139. The room should be lighted from two sides if convenient, so that the light may penetrate each corner; but if it can be illuminated from only one side or the end, the windows should be spread apart in order to diffuse the light as much as possible, as otherwise objects will cast strong shadows and numerous dark corners will result. Where the light is from the end of the room, it shines into the eyes of not more than one person seated at the table, whereas if it is from the side of the room, all persons sitting at one side of the table will be subject to the glare.

The dining room should never face the west, because the setting sun will shine directly in the room at the hour of the evening meal and in the morning, particularly in winter, the room will be dark and cheerless. When the windows open to the east or the southeast, the first rays of the rising sun will make the room cheerful on the winter morning, and at the hour of the evening meal in summer, the sun will pass around sufficiently to leave the room cool and inviting.

140. Pantry.—The dining room should communicate with the kitchen directly through the pantry, or if on another floor, by means of a dumb waiter. The dumb waiter should never open directly into the dining room, but into the pantry at the side of the dining room, as the noises from the kitchen will ascend the dumb-waiter shaft and annoy the diners. Where communication is had with the kitchen through the pantry, the doors should be arranged so that no person can see through the pantry into the kitchen even when both doors are open. The pantry should contain a sink, a table,

and closets for china and linen. The closet for the dishes may have either swinging doors or sliding doors, the latter being preferable, as they take up less room. The sink in the pantry should be of porcelain or enameled iron, and in it all the fine china from the dining room is washed and then drained on a wooden drip board located at one end or at both ends.

141. Drawing Room.—The drawing room, or parlor, should be conveniently near the dining room, although not necessarily connected with it. In small houses of an unpretentious character, the two rooms can be advantageously connected by means of sliding doors or an open archway screened with curtains; but in larger and more pretentious residences, it may be of advantage to have the parlor separated entirely from the dining room.

The distinction between the terms drawing room and parlor is a simple one, although according to custom, the latter term usually refers to a less formal apartment. The term *drawing room* is derived from the late feudal times when an apartment was cut off from the great hall and termed a *withdrawing room*. The term *parlor* is of French origin, and means a conversation room, from *parler*, to speak. In either case, the derived meaning is the same.

The size of the parlor depends of course on the character of the house and the number of persons that are likely to occupy it at one time. An oblong room admits of a better decorative treatment.

In grouping the parlor windows, liberal wall space should be maintained, as this is the room where formal pictures are hung. The windows of the parlor should also be arranged so far as possible to command the finest view. The entrance doors should be wide and liberal, otherwise the interior will have a box-like appearance. If there is to be a music room, a library, and a morning room in the house, it will probably be advantageous to have these rooms connect directly with the parlor or be near it, in order that all may be thrown together for the purpose of entertaining. Where there is only a library to connect, it may be shut off by means of a

pair of folding doors, over which portières should always be hung on the parlor side, for the double purpose of deadening the noise of conversation and of relieving the parlor of the unhospitable aspect of two tightly closed doors.

142. Library.—Every house should have a room set apart to the use of books. In some cases it is the study room for the school children, or it may be a reading room for the adults or a study for the professional man. Movable bookcases are sometimes provided, and in other cases they are built in. The shelves in either kind should be adjustable, so that they may be raised or lowered to suit the sizes of books. The top shelves should not be more than 7 feet from the floor, except where the number of books is great, under which condition the shelves may extend to the ceiling.

Windows should be considered so that all the book shelves receive ample light, the direction of that light depending entirely on the use to which the room is put. For a study that is to be occupied a large part of the time, a north light is satisfactory, owing to its evenness and freedom from sunshine. The position of the library on the plan, however, depends entirely on its purpose, in some cases being a private room and in other cases, a family room requiring publicity.

143. Billiard Room.—A billiard room is governed in its proportions by the size of the table it is to contain. The regulation billiard table measures 5 ft. × 10 ft., although a smaller size, 4½ ft. × 9 ft., is frequently used in residences. There must be a space of at least 5 feet between the edge of the table and the wall, but 7 feet at the sides and 6 feet at the ends would make a better proportion for the room. Therefore, 15 ft. × 20 ft. is as small a room as can be conveniently used for a billiard table, and this dimension does not admit of any provision for spectators that would materially interfere with the game if they were permitted to encroach on the 5-foot limit. Where possible, a platform 3 feet wide should be provided, either in the recess of a bay window attached to the room, or against one wall at the side

or end of the room, which must be extended 3 feet to provide for it.

The lighting of this room is of vast importance. Where it can be built in an extension one story high, a skylight affords the best means of illumination. Where an extension cannot be provided, the room can be arranged for in the second story, or even in the third story, in order to bring it under a roof, otherwise it will have to be illuminated by windows high up in the sides of the room so that the shadows cast by the balls will fall beneath them.

144. Music Room.—The music room may be anything from a small apartment set aside for instruction and practice to a large room for the entertainment of guests. Its shape is of little importance, but it should connect through a wide opening with some other room if its dimensions are small. The square grand piano is 7 ft. × 3 ft. 6 in., whereas the upright piano is 5 ft. × 2 ft. 6 in. These dimensions should be taken into consideration in laying out a small room exclusively for piano accommodation. In a large music room, the floor should always be of hardwood, over which rugs may be laid, except during entertaining at a formal concert, when the floor should be bare on account of acoustic properties.

145. Kitchen.—The kitchen is in many respects the most important factor in the domestic economy of the establishment. The range must be placed where it will receive the best light, have plenty of working space around it, and be convenient to the sink, work table, and dresser. If the range in the kitchen can be lighted from two opposite sides, it makes a very desirable arrangement, producing excellent ventilation during warm weather and preventing dark corners.

The store room opening out of the kitchen should have a window of its own, preferably toward the north, so that the sun cannot shine in and make it unduly warm in summer.

A great mistake of some architects is to leave the planning of the location of the kitchen until the rest of the details of the house has been settled, whereas the first consideration

should be given to the location of the kitchen and the dining room. The kitchen should be in the north or northeast corner of the plan if possible, with at least one of its windows opening in a direction that will admit the sunshine. It should never be placed in the northwest corner of the house, as it will invariably be hot during the summer afternoons.

The laundry should always be separated from the kitchen, and although laundry work is performed only once a week, there should be a separate room for this purpose, so as not to interfere with other household duties.

146. Bedrooms.—Another mistake is frequently made in the designing of bedrooms. The first consideration should be a suitable location for the bed, which should be placed beyond the line of all possible drafts and at the same time in a position where it cannot be seen from the hall when the door is half open. A double bed is 6 feet 6 inches long and 4 feet 6 inches wide; a single bed is 2 feet 8 inches wide and 6 feet 4 inches long. A bed should be placed with its head to the wall, and both sides should be open and free, so that it may be easily made up. A bureau is 4 feet 6 inches long and 2 feet wide, and it should usually be placed between two windows.

The location of bedrooms should be given careful study, as there is a great choice of positions on the plan. There are generally at least two rooms on the second floor that open into each other, with a dressing room between, and this is located near the top of the main stairs. Where there is to be a nursery, it should be near these family rooms, as should also the bathroom. The guest rooms should be near and in plain sight of the staircase.

147. Bathroom.—In designing the bathroom, it is best to be liberal and have it too large rather than too small. The bathroom is not a luxury, but a modern necessity, and it must be so placed that it will give a direct line for waste pipes and protect them from exposure in cold weather. This room should also be convenient to the principal bedrooms, and should be near the top landing of the main stairs. The

supply and waste pipes must run in a direct line from the second-story fixtures to the cellar. The bathroom should be well lighted and should have a sunny exposure. Where possible, the walls and floors should be of tile. Bathtubs are from 5 feet to 6 feet 6 inches in length and 3 feet 3 inches in width. Slabs for wash basins vary in size, but the smallest convenient size for a 14-inch basin is 21 inches in width and 24 inches in length. All these should be drawn to scale on plans, so as to observe carefully their general effect.

METHODS OF PLANNING

148. In designing a building, the first detail that usually receives the architect's attention is the plan. This is due to the fact that the problem generally demands a certain fixed arrangement of certain rooms of a certain size and proper corridors and passages to reach them. For this reason, the plan is frequently considered as the detail of most importance in the solution of the architectural problem. This method is wrong and is likely to lead to serious difficulty with the interior and exterior details if those details are left out of consideration until after the plan is complete. The plan is a mere incident in the whole design, and must not absorb all the attention while studying the problem. Every detail of the plan must be carefully considered as a possibility in the resulting whole as it is worked in place. The arrangement of the apartments to suit the future occupants of the building must be accomplished with a full regard for the effect that arrangement will have on the general effect of the whole.

In working out the plan of the building, the architect should consider it simply as a horizontal section of the whole structure he has pictured in his mind. Thus, the resulting elevations will work out themselves and there need be no cutting and fitting afterwards to make one fit the other, as is often the case.

The successful design can be reached only when the plans, elevations, and sections are carried along at one time. The

preliminary sketches are worked out for the sake of the masses, the grouping and effect of these masses being studied at one time in all drawings. Then preliminary block plans can be worked, introducing the more important details, and, finally, the full-scale working drawing, all started with the full knowledge that the masses and minor details will fall into their proper places without forcing or changing.

149. In studying these preliminary plans and sketches, there is only one method of attaining the best results, and that is by tracing and retracing every part of the design and studying the effect of these traced parts in combination with every new detail or proposed detail.

In studying out the plan, it should be borne in mind that it is more than a mere diagram of the convenience of arrangement of the rooms. In it are expressed many of the artistic details of the decorative treatment of the entire interior. The sizes of the rooms will determine the height of the ceilings, and as some large rooms may demand an appearance of greater loftiness than can be conveniently provided for, the immediate suggestion is to introduce a pilaster treatment in the side wall. These pilasters must be indicated in the plan, as they will influence the spacing of the doors and windows. But, again, these doors and windows may affect the treatment of the exterior wall, and the elevations must also be considered when the plan is worked out.

The proportioning of the rooms as to their length and breadth is also a detail of esthetic importance, and will determine to some extent the location of the partitions and subdivisions in the second story. Therefore, the second-story plan, and consequently its elevations, must be worked out at the same time as the rest of the structure.

150. In planning a series of rooms, they should always be laid out on axial lines, and the leading architectural features of the plan should be located on these lines, so as to provide a symmetrical arrangement. *Symmetry* is a most desirable characteristic of a plan of a building, and is best attained

through simplicity. Complicated and irregular plans are evidence of carelessness or inability, whereas satisfactory results attained in the simplest manner are evidence of ingenuity. The highest art and skill are required to satisfy all the complicated demands of an important building in a plan, the drawing of which seems to have been carried out on the simplest possible lines, all parts fitting exactly into place without force or makeshift. By studying the plans of the great Greek temples, the Renaissance palaces, and the Gothic cathedrals it will be possible to observe the simple manner in which all the varied and complex parts are united into a harmonious whole.

151. Symmetry in architectural design does not necessarily mean duplication of parts on opposite sides of an axial line. It is simply a detail in composition requiring that principal parts of equal importance shall receive equal attention in their design and arrangement. The four sides of the Parthenon are symmetrical, and consequently the building is conspicuous for its simplicity.

A treatment somewhat akin to symmetry is *balance*, where two objects of equal importance are introduced into the plan on opposite sides of an axial line to balance each other, although they may in no way be symmetrical. For instance, a fountain in one recess in a monumental hallway might be balanced by a group of statuary in an opposite recess.

Where neither symmetry nor balance can be attained, the other extreme should be attempted; that is, an endeavor should be made to design the opposing details as unlike as possible. In this way, it will be possible to arrive at results that have no feeling of cramped or forced work, and the plan becomes monumental in effect.

152. A *monumental plan* is one that produces a feeling of vastness, without restriction in any part. Simplicity of arrangement, symmetry of design, and balance of principal details combine to produce this monumental effect. The approaches, entrance stairway, and halls are the first part of a building that meets the public eye, and as first impressions

count for much, these details should be dealt with in a monumental manner.

On entering the French and English cathedrals, a decidedly different impression is gained, owing entirely to the liberal openings of the French edifices as compared with the cramped doorways that admit the public to the English structures.

These are considerations that apply in their way just as much to the private residence as to the public hall. Even in country houses, the entrance hall constitutes a large rectangular room with an imposing stairway, instead of the narrow tunnel-like passage, half choked by a narrower stairway, that characterized the American residences of half a century ago.

EXERCISE IV

Prepare a design for the plan and one elevation for *one* of the following buildings. The drawing is to be neatly rendered in wash or color and rooms and other details properly lettered.

(*a*) A small museum for a corner lot 75 ft. × 100 ft., to contain four separate rooms for the exhibits, besides a curator's office, public coat room, toilet rooms, etc.

(*b*) A small library on a corner lot 75 ft. × 100 ft., to contain a stack room, two reading rooms, a reference room, an office for the librarian, a retiring room for his assistants, and a public lavatory.

(*c*) A small art gallery on a lot 50 ft. × 100 ft., to contain a room for paintings, a room for sculpture, a public coat room, offices for the custodian and curator, and a public lavatory.

These designs are to be drawn to any convenient scale that will show the details, and are to be finished and rendered similarly to the bank problem in Figs. 77 and 78.

A SERIES OF QUESTIONS

RELATING TO THE SUBJECTS
TREATED OF IN THIS VOLUME.

It will be noticed that the questions contained in the following pages are divided into sections corresponding to the sections of the text of the preceding pages, so that each section has a headline that is the same as the headline of the section to which the questions refer. No attempt should be made to answer any of the questions until the corresponding part of the text has been carefully studied.

BUILDING STONE

EXAMINATION QUESTIONS

(1) What is trap and what is its principal use?

(2) What is a bush hammer and for what is it used?

(3) What is a crandall?

(4) Give a sketch of one style of rusticated work.

(5) What is marble and what are its uses?

(6) What is a patent hammer and for what is it used?

(7) What is rubbed work?

(8) What effect has hornblende on the granite that contains it?

(9) What stone is best adapted for wet places, and why?

(10) What is pitch-faced work?

(11) Sketch an example of vermiculated work.

(12) Describe the properties and uses of granite.

(13) What stone will best endure fire?

(14) What is a margin?

(15) Explain the uses of the sand blast and its methods of operation.

LATHING, PLASTERING, AND TILING

EXAMINATION QUESTIONS

(1) What are plaster boards and what are their advantages and disadvantages?

(2) What is fine stuff?

(3) What are the advantages of hard plasters?

(4) Why are wooden laths nailed so as to leave a space between them?

(5) What is the objection to using overburned lime in plaster work?

(6) Define and describe brown coat.

(7) Describe the method of making cornices.

(8) What are the usual dimensions of wooden laths?

(9) What is plaster of Paris and how did it get its name?

(10) What are screeds?

(11) Describe the method of making scaglióla.

(12) What are the advantages of metal laths over wooden laths?

(13) (*a*) What is a hawk? (*b*) What is a derby?

(14) How is rough-sand finish produced?

(15) What methods are used to prevent dust corners in hospital wards that are tiled?

COMMON BRICKWORK

(PART 1)

EXAMINATION QUESTIONS

(1) In laying brick with a frog, how are the brick placed?

(2) What is the object of pointing?

(3) What is a withe?

(4) How are brick made by the stiff-mud process?

(5) What thickness of mortar joints should be used in common brickwork?

(6) Name the four classes of brick found on opening a brick kiln after burning.

(7) Describe three kinds of anchors for anchoring beams to brick walls.

(8) What are sand-lime brick?

(9) What is Flemish bond?

(10) What is the chief requisite of a good joist hanger?

(11) (*a*) Describe two methods of striking a mortar joint. (*b*) Which is the better method?

(12) Describe one method of bonding hollow walls.

(13) What is running bond?

(OVER)

(14) What is the principal defect of running bond?

(15) (*a*) What are pressed brick? (*b*) For what are they used?

(16) What is English bond?

(17) How are glazed brick made?

(18) What is the average weight of: (*a*) a common brick? (*b*) a pressed brick?

(19) Name some of the things an architect should watch in superintending the erection of brickwork.

(20) (*b*) What is a stretcher? (*b*) What is a header? (*c*) What is a course?

COMMON BRICKWORK

(PART 2)

EXAMINATION QUESTIONS

(1) What is a party wall?

(2) Explain how brick piers are bonded.

(3) Why are curved flues preferable to straight ones?

(4) How thick must curtain walls be made in New York City?

(5) What can be said about wooden lintels?

(6) What is a curtain wall?

(7) What kind of brick are used for nogging and why?

(8) A dwelling in New York City is to be 58 feet high; how thick must the brick walls be?

(9) In building houses with veneered walls, what width must be added to the foundation over that which would be required for a frame house?

(10) What is the relation between the area of the flue and the fireplace opening?

(11) What should be the relation between the thickness of an outside wall of a building and the thickness of a party wall?

(12) What is the advantage of brick nogging?

(13) What is the advantage of a hollow brick wall?

(14) Explain the disadvantages of putting a window directly under a pier in a wall.

(15) What is a sweeper in chimney construction and what is its use?

ORNAMENTAL BRICKWORK AND TERRA COTTA

EXAMINATION QUESTIONS

(1) What is the effect of using mortar of a different color from the bricks?

(2) Explain, and show by sketch, why the joints of arches made with common bricks are wedge-shaped.

(3) Why is it wrong to put an arch in the corner of a building?

(4) Explain two methods of protecting the top bricks of belt courses from the weather.

(5) What is the spandrel of an arch?

(6) What is a vault?

(7) Name five methods by which ornamentation in brickwork may be obtained.

(8) What is the intrados of an arch?

(9) What is the objection to building an arch over a window near the end of a wall?

(10) What is the practical limit to the size of pieces of terra cotta that can be obtained?

(11) What is a relieving arch and why is it so called?

(12) Is it better to use rubbed, or molded, bricks in arch construction and why?

(13) Explain briefly the manufacture of terra cotta.

(14) Explain various methods of rendering brickwork waterproof.

LIGHTING FIXTURES

EXAMINATION QUESTIONS

(1) Into what five groups are gas and electric fixtures usually divided?

(2) How are fixtures that are employed for gas and electric lighting purposes usually distinguished?

(3) Describe briefly the difference between the construction of a stiff gas bracket and a swinging bracket.

(4) Name the component parts of an ordinary electric bracket, similar to that shown in Fig. 8.

(5) Describe the construction of a combination gas and electric bracket.

(6) How can a proper diffusion of the light emitted by either gas or electric lamps be obtained?

(7) Briefly describe a toilet chandelier.

(8) Describe the method of making art glass employed in shade construction.

(9) How are sun lights or large groups of burners usually lighted?

(10 How can the ceiling of rooms in which gas is used for light be protected from discoloration?

(11) Describe briefly the method employed in bending and brazing the arms of gas fixtures.

(12) Describe the process of burnishing and lacquering brass and bronze fittings that are employed in the manufacture of lighting fixtures.

USE AND DESIGN OF LIGHTING FIXTURES

EXAMINATION QUESTIONS

(1) Where did the Mission style of ornament originate?

(2) Give the characteristics of Roman ornament.

(3) What kind of fixtures are considered proper for parlors and reception rooms, and what is the usual disposition of them?

(4) What kind of fixtures are used for card rooms?

(5) What is very necessary to consider in designing fixtures for public buildings?

(6) What are the approximate dates of the existence of Gothic ornament?

(7) What are the usual methods of making sketches for clients?

(8) From what sources did the Greeks derive inspiration for their ornament?

(9) What is L'Art Nouveau?

(10) What rules and regulations are embodied in the usual lighting-fixture specification?

(11) What are the proper heights for chandeliers and brackets?

A KEY

TO ALL THE QUESTIONS AND EXAMPLES
INCLUDED IN THE
EXAMINATION QUESTIONS IN THIS VOLUME.

It will be noticed that the Keys have been given the same section numbers as the Examination Questions to which they refer. All article references refer to the Instruction Paper bearing the same section number as the Key in which they occur, unless the title of some other Instruction Paper is given in connection with the references.

BUILDING STONE

(1) See Art. 6.

(2) See Art. 29.

(3) See Art. 29.

(4) See Art. 46.

(5) See Art. 8.

(6) See Art. 29.

(7) See Art. 41.

(8) See Art. 2.

(9) See Art. 18.

(10) See Art. 33.

(11) See Art. 44.

(12) See Art. 3.

(13) See Art. 22.

(14) See Art. 34.

(15) See Art. 44.

LATHING, PLASTERING, AND TILING

(1) See Art. **15.**

(2) See Art. **26.**

(3) See Art. **45.**

(4) See Arts. **4** and **7.**

(5) See Art. **17.**

(6) See Art. **34.**

(7) See Art. **46.**

(8) See Art. **6.**

(9) See Art. **20.**

(10) See Art. **34.**

(11) See Art. **50.**

(12) See Art. **9.**

(13) See Art. **21.**

(14) See Art. **38.**

(15) See Art. **65.**

COMMON BRICKWORK
(PART 1)

(1) See Arts. 2 and 25.

(2) See Art. 30.

(3) See Art. 49.

(4) See Art. 5.

(5) See Art. 25.

(6) See Art. 44.

(7) See Art. 56.

(8) See Art. 17.

(9) See Art. 41.

(10) See Art. 53.

(11) See Art. 7.

(12) See Art. 28.

(13) See Arts. 47 and 48.

(14) See Art. 2.

(15) See Art. 18.

(16) See Art. 42.

(17) See Art. 55.

(18) See Art. 9.

(19) See Art. 40.

(20) See Art. 58.

COMMON BRICKWORK

(PART 2)

(1) See Art. **7**.

(2) See Art. **16**.

(3) See Art. **24**.

(4) See Art. **9**.

(5) See Art. **19**.

(6) See Art. **8**.

(7) See Art. **17**.

(8) The wall shall be not less than 16 inches thick in the story next above the foundation walls and from thence not less than 12 inches to the top. See Art. **2**.

(9) See Art. **11**.

(10) See Art. **23**.

(11) See Art. **7**.

(12) See Art. **17**.

(13) See Art. **6**.

(14) See Art. **14**.

(15) See Art. **31**.

ORNAMENTAL BRICKWORK AND TERRA COTTA

(1) See Art. **2.**

(2) See Art. **18.**

(3) See Art. **32.**

(4) See Arts. **9, 10,** and **11.**

(5) See Art. **17.**

(6) See Art. **33.**

(7) See Art. **1.**

(8) See Art. **17.**

(9) See Art. **31.**

(10) See Art. **47.**

(11) See Art. **29.**

(12) See Art. **22.**

(13) See Arts. **44** and **45.**

(14) See Arts. **40** and **41.**

LIGHTING FIXTURES

(1) See Art. **5.**

(2) See Art. **6.**

(3) See Arts. **7, 8, and 9.**

(4) See Art. **10.**

(5) See Art. **12.**

(6) See Art. **22.**

(7) See Art. **40.**

(8) See Arts. **49, 50, and 51.**

(9) See Art. **79.**

(10) See Art. **81.**

(11) See Art. **93.**

(12) See Arts. **99 and 100.**

USE AND DESIGN OF LIGHTING FIXTURES

(1) See Art. **47.**

(2) See Art. **28.**

(3) See Art. **7.**

(4) See Art. **12.**

(5) See Art. **1.**

(6) See Art. **33.**

(7) See Art. **53.**

(8) See Art. **27.**

(9) See Art. **52.**

(10) See Art. **54.**

(11) See Art. **22.**

INDEX

NOTE.—All items in this index refer first to the section (see the Preface) and then to the page of the section. Thus, "Acme Plaster, §38, p26," means that acme plaster will be found on page 26 of section 38.

159—34

G

Q

R

S